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2022/23 KSP Policy Consultation Report

Ghana

Developing Accra Marine Drive as a Model Smart City in Ghana

Ministry of Economy and Finance

KDI Korea Development Institute

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2022/23 KSP Policy Consultation Report

Developing Accra Marine Drive as a Model Smart City in Ghana

Preface

Knowledge is an essential ingredient in a country's economic growth and social development. Of particular importance is a government's capacity to formulate and implement policies. The global society is focused on implementing the Sustainable Development Goals (SDGs), which promotes knowledge sharing between countries in order to improve their policy capacity and to tackle development issues and enhance global prosperity.

Indeed, knowledge has taken on an ever-greater importance as the world continues to confront countless challenges in the post-Covid-19 era including escalating climate change, global supply chain disruptions, and economic instability. In order to effectively tackle and resolve such global problems, knowledge sharing and capacity building cannot be underestimated.

When it comes to Korea's economic development, knowledge laid the foundation for the unprecedented transformation from a poor agro-based economy into a modern industrialized one with an open and democratic society. Technology transfer from abroad and educational investments helped expand the domestic knowledge stock and made this transformation possible. The Korean government accumulated invaluable practical lessons not found in conventional textbooks through trials and errors in its course of economic development.

Capitalizing on these lessons, Korea's Ministry of Economy and Finance (MOEF) introduced the Knowledge Sharing Program (KSP) in 2004 to share Korea's development experience with the international community through joint research, policy consultations, and capacity-building activities. The program has played a vital role in supporting socio-economic development of partner countries around the world.

Since the program's launch, Korea Development Institute (KDI) has participated in implementing the KSP and has been working with more than eighty foreign countries. KDI, Korea's leading think-tank with extensive experience in policy research, has provided solutions to the challenges that partner countries face in a variety of fields ranging from industrial development to digital transformation. In the 2022/23 KSP cycle, KDI carried out twenty-two policy consultation projects in a variety of areas including digital and green economy.

Among the twenty-two 2022/23 KSP projects, one in particular is worth highlighting, which was initiated by Ghana's Ministry of Finance, Office of the President and titled, "Developing Accra Marine Drive as a Model Smart City in Ghana." Based on the Ministry of Finance and Office of the President's request, the MOEF and KDI organized a research team consisting of Ghanaian and Korean experts. The team

conducted an in-depth analysis of internal and external policy environments, identified Ghana's key development challenges, and offered policy recommendations and action plans.

On behalf of KDI, I would like to express my deepest appreciation to the Government of Ghana and the Ministry of Finance, Office of the President for their collaboration in the project. In particular, I would like to extend my profound gratitude to His Excellency President Nana Akufo-Addo, His Excellency Minister Ken Ofori-Atta, and Dr. Kwame Nyantekyi-Owusu, Marine Drive Project (MDP) Coordinator at the Office of the President for their unwavering support. The completion of this project would not have been possible without their devotion. I also wish to thank the KSP consultation team—Senior Advisor Dr. Manhee Han, Principal Investigator Professor Jinhyun Hong, Dr. Jihyeon Lee, Dr. Jongkyu Lee, and Dr. Joonho Ko for producing this report.

This project benefited greatly from many others both inside and outside the Ghanaian government, including Mr. Louis Amo, Chief Economic Officer at the Ministry of Finance. I would like to extend my sincere thanks to all who have made valuable contributions to a successful completion of the project. I am also grateful to the Center for International Development of KDI, in particular Executive Director Dr. Jungwook Kim, Project Manager Dr. Euiyoung Shon, and Project Officer Mr. Chiyeong An, for their hard work and dedication to the project.

I firmly believe that the KSP will serve as a stepping stone to further elevate mutual learning and economic cooperation between Ghana and Korea, and hope it will contribute to their sustainable development.

Cho, Dongchul
President
Korea Development Institute

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The 2022/23 KSP with Ghana

Chiyeong An (Korea Development Institute)

The 2022/23 KSP with Ghana

Chiyeong An (Korea Development Institute)

Ghana is pursuing policy to emerge as a critical hub for West African investment, tourism, and technology. It aims to develop fresh growth pathways through digital advancement and tourism expansion. The Marine Drive Project (MDP) is a leading venture proposed for the Ghanaian government's digital policy, tourism promotion, foreign investment attraction, and urban development to spread successful case studies in urban development to Accra and the rest of the country.

The MDP and the Accra Regional Urban Renewal Project are the most significant projects of the Ghanaian government since its establishment, but progress has been slow. The first phase was to be completed by 2020 but infrastructure development, tourism, and employment progress have been minimal. In response, the Office of the President and Ministry of Finance requested policy consultation on developing a smart city in Accra and the MDP region.

So the 2022/23 KSP with Ghana focused on recommending a smart city roadmap for Accra and the MDP with suggestions of specific infrastructure and policy based on Korea's development experiences. The details of the project are below.

Subtopics	Researchers	Consultants in Ghana
Smart City Master Plan in Marine Drive Project	Jinhyun Hong (University of Seoul) Jihyeon Lee (University of Seoul)	Kwadwo Yeboah (Land Use & Spatial Planning Authority)
Digital ICT Master Plan in MDP Area	Jongkyu Lee (Institute for Future of the State)	Andrew Ayitey Okoe Bulley (NexGen Limited)
Smart Public Transportation Plan in MDP Area & Accra	Joonho Ko (Hanyang University)	Samuel Boamah Danquah (Koforidua Technical University)
Senior Advisor: Manhee Han (Former First Vice Minister of Korea's Ministry of Land, Transport and Maritime Affairs) Project Manager: Euiyoung Shon (Visiting Senior Fellow, Center for International Development (CID), Korea Development Institute (KDI)) Project Officer: Chiyeong An (Research Associate, CID, KDI) Principal Investigator: Jinhyun Hong, Professor (Univ. of Seoul)		

This project kicked off in Accra on November 28, 2022, with a launching seminar attended by representatives from Ghana's Office of the President and the Ministry of Finance. During the workshop, Korean researchers presented comprehensive research plans covering urban development, innovative finance, and intelligent public transportation within Ghana, fostering collaboration. After the seminar, thorough interviews with senior officials and experts in the country were conducted on the smart city concept for Accra and the MDP, including the Office of the President, Ministry of Finance, private e-payment company MTN, Ghana Tourism Authority, Land Use and Spatial Planning Authority, Ghana Interbank Settlement Company, and key ministries.

A KDI team visited the African country to attend a Policy Seminar and In-depth Study of Ghana from February 11-17, 2023, encompassing a meeting and detailed fact finding to enhance familiarity with issues in the country. At the seminar, content from ongoing research was presented that incorporated feedback. The engagement extended to relevant regional organizations to lead to additional interviews and fact finding on pertinent topics. Detailed budgets and short- and long-term plans for the MDP project were discussed focused on the applicability of the Korean experience to Ghana.

The third step of the KSP project—the Interim Reporting and Policy Practitioners' Workshop—was held in Korea. From April 17-21, 2023, a Ghanaian delegation of members from the MDP Project Team from the Office of the President, Ministry of Finance, Accra Metropolitan Assembly, and Ministry of Communication and Digital Affairs visited Korea. This visit facilitated a policy training session and interim report, including visits to pertinent organizations and sites that could serve as models for coastal tourist destinations for the MDP. At the workshop, deliberations centered on enhancing connectivity within the MDP area and expanding the scope of application. Talks on key outcomes culminated in clarifying

specific budgets and infrastructure quantity for the MDP zone's short-term development.

As the final step of the KSP project, the KDI team visited Accra from July 17-21, 2023, for a final reporting workshop. Korean researchers presented their policy recommendations as a long-term plan to develop Accra as a model smart city focused on the MDP zone. They also suggested agreed-on short-term recommendations to set up relevant infrastructure for a smart city with detailed information as an estimate to implement the MDP as an urban development project.

This policy report will be used to implement the MDP as a smart city framework and provide comprehensive answers to complex urbanization challenges in Accra. This presents a concrete path toward progress within the MDP area through a well-defined roadmap encompassing immediate and future endeavors, including detailed budget information. These policy recommendations can help overcome challenges to propel the MDP and Accra's transformation into smart cities.

Executive Summary

Jinhyun Hong (University of Seoul)

Executive Summary

Jinhyun Hong (University of Seoul)

This project within the 2022/23 KSP with Ghana was conducted under the title “Developing Accra Marine Drive (MDP) as a Smart City Model in Ghana.” Its main purpose is to provide the Ghanaian government with useful and hands-on recommendations for use in developing the MDP as a smart city.

Three sub-projects were developed. The first (Topic 1) aims to develop a comprehensive smart city plan for the MDP based on Korean smart city policy and project experience. Specifically, it covers nine key strategic areas: smart water, smart safety, smart environment, smart mobility, smart living, smart datahub, smart infrastructure, smart governance, and smart economy. Among them, smart economy is covered in detail in Topic 2 and smart mobility in Topic 3. For each strategic area, detailed directions, specific technologies, and Korean examples are presented. This topic proposes 12 short-term recommendations for six key strategic areas—smart safety, smart environment, smart mobility, smart living, smart datahub, and smart infrastructure—selected based on the MDP’s priority, feasibility, budget constraints, and research scope.

For smart safety, installation of surveillance (CCTV) cameras and smart pole is proposed. CCTVs are the most widely used and effective way to raise safety and see improvement in issues like crime, disasters, and child protection. Based on the MDP’s conditions, the installation of a combined 53 CCTVs is recommended at a combined cost of USD 1.3 million. In addition, a CCTV control center costs about USD 1 million. A smart pole consists of smart city ICT such as Wi-Fi, CCTVs, electric charging, and streetlights and its prices vary according to the technologies included in the pole.

In Korea, smart environment uses two types of Internet of Things-based (IoT) sensors to measure air pollution. Specifically, the first is expensive high-performing sensors installed at certain locations to effectively measure the overall level of air pollution in a city but

limited to variations of the area. To overcome this handicap, detailed information on the estimated 1,000 S-DOT sensors installed in Seoul is included with the cost. The importance of setting emission standards is also discussed. While sensors can be installed to measure and continuously track air pollution levels, in the end, active cooperation between the private and public sectors is needed to recognize the seriousness of air pollution and reduce pollutant emissions.

The bus rapid transit (BRT) system in smart mobility is discussed in detail in Topic 3, which covers other recommendations such as a bicycle sharing program, street design planning, and smart parking system. Technology and costs for an underground parking system are examined since the MDP will have big underground parking lots for residents, workers, and visitors.

The MDP area will be a leading tourist attraction in Accra, requiring adequate levels of services for both residents and tourists. For smart living and infrastructure, technologies for waste, rest areas, internet connection, and amusement are covered. Smart bin and bench are examined to solve potential waste problems in Accra and provide rest places near the ocean. Public Wi-Fi, 3D screens, and interactive floor display technologies are reviewed to improve visitor satisfaction. The presentation of detailed costs for each technology can help the Ghanaian government make decisions based on its preferences. Finally, a study on datahubs is conducted, something appropriate not just for the MDP but also if the Ghanaian government wants to expand smart city projects nationally.

The second sub-project (Topic 2) assesses the financial system in Ghana and presents strategies for building digital finance infrastructure in the MDP area. Such infrastructure is the backbone of a successful economy but requires long-term investment. The topic reviews literature on the relationship between smart cities and digital payment systems and provides scientific evidence on the long-term need for a new digital payment system to enhance the functioning of Ghana's smart cities.

The report contains detailed analyses of Ghana's payment systems like mobile money (MM) and feasibility of use in the MDP. MM is widely used by Ghanaians, especially those living in rural areas, though the Ghanaian government has promoted digital payment systems since the 2000s. The analyses showed that the MM-reliant payment system is unsuitable for supporting financial activities in urban areas. Given new demand for financial transactions in smart cities, Ghana's payment systems face inevitable change for the successful setup of smart cities.

The report offers practical recommendations to reshape the MDP's payment system. The main proposal is a multi-channel banking system with a wide variety of payment instruments and channels that allow more user flexibility. To achieve this, the report suggests creating a payment council, an executive decision-making body consisting of financial institutions as members, to devise specific action plans based on the Korean experience.

Finally, the third sub-project (Topic 3) develops strategies to improve the public transportation system in Accra and plans for the MDP area. Significant increases in population and car ownership in the Greater Accra area have led to inefficient public transportation, resulting in traffic, environment, and health issues. Trotro, or minibus shared taxis, is the main mode of public transportation in Accra with the most extensive network, but also has serious challenges such as overcrowding, erratic schedules, and operational issues. The BRT system in Accra does not work well partly due to insufficient infrastructure and improper operating systems.

The focus of this topic is creation of a reliable, green, smart, affordable, and convenient public transportation system in the MDP area, with short- and long-term recommendations provided. Over the short term, the report suggests five e-shuttles running through the MDP area and connection to the commercial business district (CBD). In addition, detailed plans about the comprehensive systems for bus information (BIS), bus management (BMS), and fare collection are introduced at a combined estimated cost of USD 1.4 million.

Over the long term, the report suggests construction of a new circular BRT corridor with electric-powered buses in Greater Accra and improving pedestrian infrastructure that connects the MDP area to the CDB. For the new BRT service, four dedicated buses and expansion of specific roads are proposed.

In sum, this project offers practical short- and long-term recommendations to make the MDP the first smart city project in Ghana based on the Korean experience. Detailed action plans considering site characteristics, new technology, and costs are provided to help the Ghanaian government make effective decisions as well as form new collaborations between the two countries in selected action plans.

The estimated cost of the short-term plans for the proposed master plan for smart city and plan for smart public transportation in the MDP area is USD 4.2 million. First, the short-term plan of the master plan includes the most urgent investment needs for the MDP such as at its central building and public Wi-Fi. A combined 53 CCTV units are slated to cost USD

1.3 million and their control center USD 1 million. Another USD 200,000 will go to parking information systems and USD 300,000 to public Wi-Fi. Next, the short-term plan for smart public transportation in the MDP area and Accra will cost USD 1.4 million. These calculations provide a preliminary assessment of the financial investment needed for the short-term plan as valuable reference for budgetary considerations and potential funding sources.

01

CHAPTER

The Smart City Master Plan for the Marine Drive Project

Jinhyun Hong and Jihyeon Lee (University of Seoul)

1. Introduction
2. Overview of the Marine Drive Project
3. Comprehensive Smart City Plan for the Marine Drive Project
4. Short-term Smart Project Recommendations for the Marine Drive Project
5. Conclusions

Keywords
Smart City, Smart Strategies, Master Plan, Marine Drive Project, Smart City Technologies

The Smart City Master Plan for the Marine Drive Project

Jinhyun Hong and Jihyeon Lee (University of Seoul)

Summary

This chapter of the 2022/23 KSP with Ghana suggests a comprehensive smart city plan for the Marine Drive Project (MDP) in Accra. Prior to discussing the master plan, the case study of the development of Marine City in Busan's Haeundae-gu, which is geographically similar to the MDP area, is covered. These case studies can guide the MDP to set development directions of projects. This study's purpose is to provide the Ghanaian government with useful and practical recommendations based on Korean experience in smart city policy and projects.

The proposed plan aims to improve quality of life for the people, enhance sustainability, and streamline urban services through advanced technologies and data-driven solutions such as sensors, smart grids, and intelligent transportation systems to optimize resource use, reduce traffic congestion and air pollution, improve public safety, and foster economic development. Moreover, the plan is not limited to technical solutions but also covers intelligent methodologies and proper use of beneficial and effective solutions. This paper reviewed nine key strategic areas applicable to the MDP: smart water, smart safety, smart environment, smart mobility, smart living, smart datahub, smart infrastructure, smart governance, and smart economy.

Several short-term smart projects proposed for the MDP are based on Korean smart city policy and project experience that reflect the Ghanaian government's preferences, feasibility, and budget constraints. The focus was on six key strategic areas—smart safety, smart environment, smart mobility, smart living, smart datahub, and smart infrastructure—with 12 recommendations and their detailed cost information. They include CCTVs, smart poles, IoT-based air quality remote management systems, bicycle sharing programs, street design planning for future mobility, smart parking system, smart bin, smart bench, cloud

data center, public Wi-Fi, 3D screens, and interactive floor display. All of these smart city technologies or services are widely used in Korea and continuously expanded.

The cost estimation for the short-term plan of the proposed smart city master plan is USD 2.8 million. The plan includes the most urgent investment needs for the MDP such as those at its center building and public Wi-Fi.

First, CCTV increases public safety at a reasonable price, with many studies showing how CCTV installation is effective in reducing public fear of crime. A combined 53 cameras and their control center are estimated to cost USD 2.3 million, or USD 25,000 per unit comprising a dome camera capable of 360-degree shooting, three bullet cameras, and the control center, which costs about USD 1 million. Considering the MDP's shape and size, installation of 53 CCTV units costing an estimated USD 1.3 million is recommended. The control center integrates functions such as those of traffic, crime prevention, illegal parking management, and disaster monitoring and costs on average about USD 1 million.

Second, a parking information system (PIS) assesses the real-time situation of a parking lot and utilizes the collected data. Its two key components are 1) small sensors on the top of a lot indicating space availability and 2) an entry system that recognizes a vehicle's license plate information. Since the costs can greatly vary depending on road and infrastructure conditions, this paper only estimated the cost of installing facilities for real-time management systems inside an underground parking lot. The price was USD 17,000 to USD 25,000 per entrance and USD 210 per parking space for a parking guidance system (based on ultrasound).

Finally, public Wi-Fi is effective infrastructure for governments to connect cities, allowing people to access information they need easily and quickly by using personal devices such as laptops, tablet PCs, and smartphones. Free Wi-Fi in tourist spots also provide a pleasant experience for tourists. The coverage of one Wi-Fi repeater is a radius of 30 meters. The installation cost for one repeater at a bus stop is about USD 4,980 and the maintenance expense USD 27.5 per month. Assuming that Wi-Fi is installed at all bus stops and on the beach (every 30 meters) in the MDP area, a combined USD 298,800 is needed for installation and USD 1,650 for monthly maintenance.

1. Introduction

This research aims to devise a comprehensive smart city plan for the Marine Drive Project (MDP) in Accra, Ghana, in two main parts. First is a comprehensive plan for the MDP whose direction reflected its conditions and development of smart city technologies. The three goals of a comprehensive smart city plan for the MDP are 1) building a data-based smart city to solve urban problems such as social polarization, lack of diversity and inclusion, and pollution; 2) making the MDP the first testbed of Ghana's smart city projects with emerging technologies such as AI, IoT, and big data; and 3) building an innovative ecosystem to boost the national economy. The plan covers nine key strategic areas: smart water, smart safety, smart environment, smart mobility, smart living, smart datahub, smart infrastructure, smart governance, and smart economy.

Second, this paper's short-term smart project recommendations include practical and feasible ventures in six key strategic areas: smart safety, smart environment, smart mobility, smart living, smart datahub, and smart infrastructure. Due to the research scope of this project, feasibility, and priorities of the Ghanaian government, the focus was placed on these six key areas among the nine. Short-term smart project recommendations were based on the Korean experience in smart city policy and projects and provide the Ghanaian government with useful and hands-on ideas like for budgeting. They include CCTVs and smart poles in smart safety; IoT-based air quality remote management system in smart environment; bicycle sharing program, street design planning for future mobility, and smart parking system in smart mobility; smart bin and bench in smart living; cloud data center in smart datahub; and public Wi-Fi, 3D screens, and interactive floor display in smart infrastructure.

2. Overview of the Marine Drive Project

2.1. Overview

The MDP is run offshore from Christianborg Castle to Baiden Powell in Osu, south of the capital Accra, covering 241 acres (98 ha) with a budget of about USD 1.5 billion. The site is located at Accra's waterfront and includes Landmark Marine Promenade and Independence Park and the Flame of Freedom, which celebrates Ghanaian independence. In addition, the Osu Castle, a leisure and business space with hotels, shopping, and fine dining, is also planned (see Figure 1-1).

The MDP is a pilot project for the Ghanaian government's policy toward digital policy, tourism, and foreign investment that is expected to create nearly 150,000 jobs directly and indirectly. The developer is Marine Metro Development, Ltd., a fully owned subsidiary of AMDEL.

As shown in [Figure 1-2], the MDP has a three-phase approach to building horizontal infrastructure including roads, greenways, sidewalks, bike paths, information and communication technology (ICT), energy, water, and wastewater management. Once all infrastructure building phases are completed, development of vertical structure led by the private sector will begin.

[Figure 1-1] Project Master Plan and Land Use

Source: Accra Marine Drive investor brochure.

[Figure 1-2] Three-phase Approach for the MDP

Source: Accra Marine Drive investor brochure.

2.2. Korean Experience: Haeundae, Busan

Haeundae New Town is the first planned city in Busan, dubbed a “new town in a town.” The project sought to supplement housing within Korea’s largest port city and create a pleasant and harmonious urban environment. Covering 939 acres (380 ha) with a development period of 1991 to 1997, Haeundae had the goal of accommodating a population of 120,000 and 33,000 households. Marine City in the city’s Haeundae-gu has many similarities with the MDP in geographical characteristics, size, and development purpose. Marine City has a high-rise skyscraper with mixed use including residential, commercial, and office.

Originally, the Korean government tried to develop Haeundae-gu as a global financial center for balanced national development and industrial innovation. Strong regulation to curb real estate speculation and the concentration of financial companies in the Seoul metropolitan area, however, made it difficult for Busan to develop into an international center of finance.

Later, Haeundae-gu was transformed into a luxury residential area with a mix of commercial facilities and tourist attractions thanks to its convenient public transportation system and beautiful natural scenery. This fits the plan envisioned by the MDP, so Marine City in Haeundae-gu was chosen as a case study for the MDP.

To create a sustainable lifecycle and comfortable residential environment, Haeundae New Town was slated to get sufficient green space and convenient living facilities and was aligned with Busan’s transportation system and urban spatial structure (see Figure 1-3). A well-connected pedestrian network was also developed to improve pedestrian convenience and safety and the walking experience in developed areas.

As mentioned earlier, the original plan for Haeundae was to build an international financial district but this was changed to a luxury residential area with commercial facilities and tourist spots. This shows the difficulty in developing a new town into a global financial district because of many factors required. Some are hard to control like economic growth and corporate decisions so the MDP might need to reconsider its objectives and keep other options open.

In addition, Marine City utilised the characteristics of the area adjacent to the sea. The project covers 205 acres (83 ha), and since the reclamation of Suyeongman Bay in the 1990s, high-end residential apartments, office buildings, and hotels have been built to form the skyline of Marine

City (see Figure 1-4). Urban cruise ships and yacht tours allow visitors to enjoy the waterfront scenery and night view of skyscrapers. As a luxury residential area and top tourist spot in Korea, both Haeundae-gu and Marine City are test beds for new technologies. [Figure 1-5] shows the plans for land use in both cities and how such uses are mixed.

[Figure 1-3] Construction Overview of Busan Planned Cities

Source: Authors.

[Figure 1-4] Four Photos of Haeundae-gu

Source: Haeundae-gu Office.

[Figure 1-5] Land Use Plans for Haeundae New Town and Marine City

Source: Hwang and Kim (1999) (left), authors (right).

3. Comprehensive Smart City Plan for the Marine Drive Project

3.1. What Is a Smart City?

To avoid mistakes made earlier by cities, urban planning must go beyond solving issues and use a future-centric and comprehensive approach covering social, environmental, and municipal issues. A smart city is "a sustainable city where a host of city services are provided based on infrastructure built by converging and integrating construction and ICT to enhance competitiveness and livability (Act on the Promotion of Smart City Development and Industry)."

[Figure 1-6] Concept of Smart City in Developed and Developing Economies

	Developed World	Developing World
Entity	Private Sector Led	Public Sector Led
Purpose	Urban Regeneration, Quality of Life, Responding to Climate Change	National Power, Economic Stimulus, Solutions for Repid Urbanization

Source: Authors.

The term “smart city” has been used worldwide with varying nomenclatures, contexts, and meanings. As shown in [Figure 1-6], smart city projects are mainly promoted by the private sector for urban regeneration, quality of life, and response to climate change in developed economies. On the other hand, such projects in developing economies are mainly developed and led by the public sector to enhance government power and solve urban problems caused by rapid urbanization.

[Figure 1-7] Composition of Urban Platform

Source: Ministry of Land, Infrastructure and Transport (2019).

In Korea, the term “smart city” has multiple definitions but the central government defines it like this: “A Smart City is an Urban Model that can solve various urban problems and improve quality of life by convergence of new technologies such as ICT and big data into cities (Ministry of Land, Infrastructure and Transport, 2019).” Approaches to urban problems are shifting from an infrastructure-focused view to a smart service perspective with extensive engagement of the public, business initiators, global partners, and others. So

another definition is an “urban platform” where innovative technologies can be combined with urban infrastructure (see Figure 1-7). Through this, services in a range of fields such as transportation, energy, environment, welfare, safety, administration, economy, and housing are provided.

3.2. Goal of the Smart City Plan for the Marine Drive Project

The goal of the smart city plan for the MDP is to create a platform for urban innovation and future growth by utilizing data and new technology. Specifically, the three goals are 1) creating a data-based smart city to solve urban problems such as social polarization, lack of diversity and inclusion, and pollution; 2) making the MDP the first testbed of Ghana’s smart city projects with emerging technologies such as AI, IoT, and big data; and 3) building an innovative ecosystem to boost the Ghanaian economy (see Figure 1-8).

To achieve these objectives, an innovative ecosystem is needed in which the public and private sectors can cooperate to maximize their resources and capabilities. Specifically, combining funding and technologies from the private sector and administrative and financial support from the government can form a public-private partnership. If the MDP produces Ghana’s first successful case study of a smart city platform, this will have a positive ripple effect not only on Accra but also other Ghanaian cities.

[Figure 1-8] Goals of Smart City Plan for MDP

Source: Authors based on information from Ministry of Land, Infrastructure and Transport (2021).

3.3. Key Strategic Areas of Smart City Plan for the Marine Drive Project

To build a smart city model for the MDP, 12 key strategic areas were identified based on the Korean experience and conditions in Accra as shown in [Figure 1-9]: smart water, smart safety, smart environment, smart education, smart mobility, smart energy, smart living, smart datahub, smart infrastructure, smart governance, smart administration, and smart economy. Certain topics, however, need long-term and complex strategies beyond the capacity of this project, so the focus went to nine of the 12 key areas (see Figure 1-10).

[Figure 1-9] 12 Key Strategic Areas of Smart City

Source: Authors.

The directions, strategies, and leading case studies of each strategic area are presented. This section excludes smart economy since this topic will be covered in detail in section 2. In addition, specific implementation plans on smart mobility vis-à-vis the public transportation system will be presented in section 3.

[Figure 1-10] Nine Key Strategic Areas

Source: Authors.

3.3.1. Smart Water

3.3.1.1. Direction

Smart water can be defined as “advanced technologies and data analysis to manage water resources more efficiently, sustainably, and effectively” (Lee, 2015). Smart water management systems can include a range of technologies such as sensors, IoT devices, and real-time data analytics in cities that monitor and manage water usage, detect leaks and other issues in water infrastructure, and optimize the distribution and consumption of water resources.

Furthermore, smart water can solve serious water-related disasters that Accra faces such as water pollution and flooding, the biggest obstacles to waterfront developments in the MDP. Sustained water pollution threatens the economic stability and growth of the sprawling metropolis of Accra and especially hinders private investment in the development of the city’s waterfront. Lack of water and sewage infrastructure and insufficient waste disposal can also cause secondary damage such as flooding, resulting in public health problems.

Growth of the urban population at the expense of adequate planning and infrastructure creates a major headache for city authorities, who seek to make Accra resilient by employing structural and non-structural flood control measures. This area, however, is rather complicated to deal with here in detail. Proper technology and management systems are needed in the MDP area given Accra’s conditions. Fortunately, K-water, a public utility run by the Korean government, conducted an in-depth study about the smart water system in Ghana. So this paper deals only with general characteristics to raise understanding of Ghanaian agencies on the basis of the smart water system.

3.3.1.2. Smart Water Strategies

Six strategies merit consideration for the restoration of a city’s natural water cycle (rain-stream-water treatment-waste water-reuse) and development of a specialized waterfront city: forecast and urban water-related disaster response systems, low impact development, stream quality improvement, smart water treatment plant, smart water management, and water recycling system. For more information on each strategy, refer to the table below.

<Table 1-1> Strategies for Smart Water System

	Strategy	Function
1	Forecast & urban water-related disaster response systems	✓ Continuous analysis of localized rainfall around city with high-precision & small precipitation forecast radar, prepare for flooding ✓ Continuous monitoring of water infrastructure such as water level, sluices, & drain system linked with cross-city operations center for implementation of integrated water-related disaster response system ✓ Real-time 3D monitoring & control of water level by underground rainwater drain system by linking with augmented city platform (digital twin)
2	Low impact development	✓ Customized green infrastructure applied to public facilities, land, & buildings (including residential structures) such as roads, parks, gardens, & streams to restore city's natural water cycle ✓ Running complete water cycle system of green infrastructure-ecological wetland-retention basin-stream in residential/district/water system levels
3	Stream quality improvement	✓ Eco-filtering system to improve water quality via MDP by filtering water naturally as it flows
4	Smart water treatment plant	✓ Implementation of new water supply system with multi-story water treatment facilities within city near users, allowing direct supply of freshly treated water
5	Smart water mgmt.	✓ Smart water management tech allowing access to real-time data on water quality & quantity during water supply process to provide user-centric services
6	Water recycling system	✓ Wastewater from households, restaurants, & industrial plants reused for cleaning to fill waterway, water parks after highly advanced treatment ✓ Recycling plant to be built in sewage treatment plant with dedicated tunnels & pressure system to supply & recover reusable water

Source: Authors based on data from Ministry of Land, Infrastructure and Transport (2021).

3.3.2. Smart Safety

3.3.2.1. Direction

Smart safety is the use of advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), and big data to enhance public safety and emergency response. It requires collecting and analyzing real-time data from sources like sensors, cameras, and social media to identify potential safety threats and respond to emergencies more effectively and efficiently. Smart safety is an important aspect of a smart city that helps reduce crime rates, improve public safety, and save lives in emergency situations.

3.3.2.2. Strategies for Smart Safety

This look at strategies using IoT infrastructure to provide smart safety services focuses on four areas: climate, crime, roads and traffic, and fire.

Climate safety involves climate and environmental monitoring, information, and emergency response strategies. Such monitoring is a continuous observation system for dangerous climate events like a flood, drought, storm, earthquake, or environmental risk such as harmful pollutants. Climate and environmental information is a forecasting and warning system for potential risks using customized climate-related real-time data on daily weather and health factors. And the emergency response uses a live camera feed from the affected location and weather alert for a heat wave.

Road and traffic safety consists of road traffic monitoring, law enforcement, and pedestrian safety strategies. Road traffic monitoring is for checking roads, reporting accidents, and providing road surface information. Law enforcement has a robot warning system for traffic light violations and enforcement functions of vehicles that commit traffic offenses with camera recording and reporting. And pedestrian safety features traffic light notifications and alerts and warnings of abnormal events like a dangerous vehicle approaching).

The crime safety sector includes tracking and monitoring of criminals, emergency service deployment, and safeguard service strategies. The first category in this sector has a system for recognition and identification and tracking of faces and plate numbers that can be utilized in determining an incident's location, finding potential escape routes, and recording video of a crime. The safeguard service can be used for both protection and prevention: protection on call with light control and camera recording and active crime prevention with blind-spot patrol with robots and drones.

Finally, the fire safety sector contains fire updates and notifications, emergency service deployment, and firefighting support strategies. The update and notification system uses real-time monitoring of fire status with intelligent CCTVs and immediate notification of fire with status and location information. And emergency service deployment is to send emergency alerts to the police (119) and fire departments (112) with a real-time camera feed from the event site.

Application of all four categories to the MDP is difficult both on an administrative and financial basis. So, this paper will focus on CCTV, an excellent and cost-effective tool among the methods to maintain public safety in a city. For more information, see section 4, Short-term Smart Project Recommendations for the Marine Drive Project.

<Table 1-2> Smart Safety Strategies

	Sector	Strategy
1	Road safety	Road traffic monitoring Law enforcement Pedestrian safety
2	Crime safety	Tracking & monitoring of criminals Safeguard service
3	Fire safety	Fire updates & notification Emergency service deployment

Source: Authors.

3.3.3. Smart Environment

3.3.3.1. Direction

A smart environment is crucial for a smart city as it optimizes resource management, enhances sustainability, increases efficiency, improves public health, raises quality of life, stimulates civic engagement, and drives economic growth. By leveraging technology and data, a smart environment can create a more livable, resilient, and future-ready cities. Because of the difficulty in resolving environmental issues, especially in developing economies where a lot of development occurs, this paper will stick to general strategies but provide detailed recommendations for IoT sensors and systems that the MDP can adopt in section 4.

3.3.3.2. Smart Environment Strategies

The strategies here for provision of smart environment services are for four areas: green transition, urban space, people, and feasibility. [Figure 1-11] shows the main components of each sector. The green transition features carbon neutrality, natural recovery, and improvement of environmental quality. In urban spaces, environmentally sensitive areas and spatial structures that could reduce environmental effects are considered. Better care for vulnerable demographics can use advanced technologies and services for use in daily life. In addition, policy actions that encourage changes in human behavior need consideration. The feasibility sector thus covers affordable technologies, economically sustainable services, and locally manageable technology.

[Figure 1-11] Direction of Smart Environment

Source: Authors based on information from Smart Green City Research Group (2021).

3.3.4. Smart Mobility

3.3.4.1. Direction

Smart mobility in a smart city is the use of intelligent transportation systems (ITS) and technologies to improve transportation efficiency, safety, and sustainability. This requires the integration of the modes of transit like public transportation, cycling, walking, and private vehicles to create a more connected and accessible urban environment.

Smart mobility solutions typically leverage data analytics, sensors, and communication technology to optimize transportation networks and improve the user experience. For example, smart mobility systems provide real-time data on traffic congestion, public transit schedules, and available parking spaces to help travelers make more informed travel decisions.

Additionally, smart mobility initiatives can help reduce the environmental impact of transportation by promoting the use of electric or alternative fuel vehicles and encouraging healthy transportation options like walking and cycling. Overall, smart mobility plays a critical role in creating sustainable and livable cities that can efficiently and effectively move people and goods. This sector is largely divided into four parts: smart roads, future transportation, smart parking systems, and last mile service (see Figure 1-12).

[Figure 1-12] Direction of Smart Mobility

Source: Ministry of Land, Infrastructure and Transport (2021).

3.3.4.2. Smart Mobility Strategies

This section considers strategies for the smart mobility areas of smart roads, future transportation, smart parking systems, and last mile service to ensure the most efficient and eco-friendly urban transportation system.

Smart roads are an ITS for self-driving infrastructure and traffic flow optimization. Cooperative intelligent transportation system (C-ITS) infrastructure is the next generation of ITS that update vehicles and alert drivers for traffic information and potentially dangerous situations, slashing the risk of traffic accidents. For traffic safety, the system features constant data sharing between vehicles and between vehicles and roads (infrastructure), real-time data for individual vehicles, and prompt and dynamic response to unexpected situations with preemptive measures. The smart traffic light system predicts traffic volume and controls traffic lights using data analytics. To implement this system, connection of an adaptive traffic light control and CCTV monitoring systems to the platform is needed.

Future mobility aims to improve the efficiency, safety, and sustainability of transportation systems using technology and big data while also enhancing the user experience for travelers. In urban and transportation planning, the key to future transportation is infrastructure for supporting future modes of transit and services such as electric and self-driving vehicles, car sharing services, on-demand public transportation, and multi-service charging stations.

A smart parking system minimizes the time required to find a parking space, cuts fuel consumption, and expands shared parking lots that can mitigate parking difficulties. Technology such as sensors, cameras, and kiosks and data improve the parking experience for both drivers and parking lot operators. Strategies include the parking information system (PIS) and shared parking lot system. More details on the PIS will be presented in section 4.

The last mile service is the final leg of a transportation system that brings people or goods from a transportation hub like a train or bus station to the final destination. For example, such a service in public transportation could be a shuttle bus, bicycle sharing system, or other options that bring people from a transportation hub to their homes, workplaces, or other destinations. This plan mainly covers means of personal mobility such as a bicycle, e-scooter, and kickboard. To promote widespread introduction of this service and secure safety, proper construction of infrastructure and regulation are required.

<Table 1-3> Smart Mobility Strategies

	Sector	Strategies
1	Smart road	C-ITS infrastructure Smart traffic light system
2	Future mobility	Electric & self-driving shuttle system Car sharing services On-demand public transit Multi-service charging stations
3	Smart parking system	Parking info system Shared parking lot system
4	Last mile service	Eco-friendly personal mobility Personal mobility stations & lanes

Source: Authors.

3.3.5. Smart Living

3.3.5.1. Direction

Smart living uses technology and data to improve the quality of daily life for residents and make cities more livable. This concept encompasses a wide range of areas like smart urban furniture, shopping and culture, and education and city apps. These smart living technologies are fast becoming essential to communities that use them to transform lifestyle and work.

3.3.5.2. Strategies

Smart urban furniture is outdoor furniture or structures found in public spaces in urban areas that provide functional and aesthetic benefits to people who use such spaces as well as sensors. Self-powered versions of such furniture on streets like smart benches can help cities and communities attract more people to public spaces.

(Smart urban furniture equipped with various sensors is outdoor furniture or structures found in public spaces in urban areas that provide functional and aesthetic benefits to people who use such spaces. Self-powered versions of such furniture on streets like smart benches can help cities and communities attract more people to public spaces.)

Smart shopping and culture can probably be felt the most in smart city planning. This strategy can turn the MDP area into a tourism center, so development of smart shopping streets with free Wi-Fi and other services is highly recommended.

Education is essential for cities and countries to foster skilled people. Smart education in smart cities is the integration of advanced technologies and digital infrastructure with education to improve the student learning experience and make education more accessible, interactive, and personalized. It aims to transform traditional teaching and learning methods by leveraging innovative technologies such as AI, IoT, augmented (AR) and virtual reality, and big data analytics.

Finally, useful smartphone apps greatly increase public convenience. An AR-based urban app allows access to every facility in a city with reservation options at the user's fingertips. In addition, the app allows the public to share their opinions and use feedback to improve services and launch new ones.

[Figure 1-13] Smart Living Strategies

Source: Authors based on information from Ministry of Land, Infrastructure and Transport (2021).

3.3.6. Smart Datahub

3.3.6.1. Direction

A smart datahub is a centralized platform or system that collects, integrates, analyzes,

and manages large volumes of data generated from a city's smart systems and devices. It is a central repository for data from a variety of sources like sensors, devices, networks, and apps deployed across the city and a layer of infrastructure that facilitates data exchange among stakeholders such as public agencies, service providers, businesses, researchers, and residents. Moreover, it shares data with other stakeholders to stimulate the development of innovative solutions to urban problems. Though this is a smart city's backbone, a smart datahub is not necessary for the MDP because of the latter's scale and types of data collected in its area.

Section 4 discussed the CCTV control center for use in the MDP area as a substitute for a datahub. A datahub is required when the Ghanaian government builds a smart city at the metropolitan level, so the next section covers the basic features of a datahub.

3.3.6.2. Smart Datahub Strategies

Key features could include:

① Data collection: A smart datahub gathers data from diverse sources including IoT devices, public infrastructure, transportation systems, environmental sensors, and social media feeds.
② Data storage and management: It provides storage and management capacity to handle the large volume, velocity, and variety of data generated in a smart city environment.
③ Data integration (standard API): This integrates data from a variety of formats, protocols, and platforms into a unified structure, allowing cross-domain analysis and correlation of data sets.
④ Data analytics: This uses analytical tools and algorithms to process and analyze collected data, extracting valuable insights and patterns for applications.
⑤ Data visualization: A smart datahub often includes visualization tools and dashboards that present data in a user-friendly manner, enabling stakeholders to understand and interpret the information easily.
⑥ Open data sharing: This promotes the sharing of anonymized and aggregated data with external stakeholders like developers, researchers, and entrepreneurs to foster innovation and create new services.
⑦ Privacy and security: A smart datahub prioritizes data privacy and security through robust measures to protect sensitive data and ensure compliance with privacy regulations.

[Figure 1-14] Smart Datahub's Roles in Korea

Source: City Data Hub (www.citydatahub.kr/).

3.3.7. Smart Infrastructure

3.3.7.1. Direction

Cities face challenges when working with conventional and old buildings, roads, and other infrastructure including digital infrastructure like broadband, mobile telecom, data centers and networks. Smart infrastructure uses digital technology and data to solve problems associated with aging and outdated infrastructure and the rise of new demand.

Digital infrastructure is a critical component of smart cities that provides access to information and knowledge, two valuable resources for personal and business growth. People can access educational resources, job opportunities, news, and other desired and important information online. In addition, digital infrastructure has greatly improved remote work and learning, transformed healthcare, provided entertainment, streamlined transportation systems, and enhanced communication.

Prior to the launch of smart cities, the process of infrastructure data utilization for each service was managed separately without integration, requiring additional investment and development to connect them as shown in [Figure 1-15]. The difficulty of applying and validating new ideas led to high cost, low efficiency, and top-down development.

[Figure 1-15] Direction of Smart Infrastructure

Source: Authors.

Smart infrastructure starts with the sharing of infrastructure elements between services. Unrestricted convergence between services not only reduces development costs, but also enables entire cities to be testing labs. The MDP needs to move away from the traditional infrastructure management method and adopt a platform-based approach to develop, change, and converge services by building shared infrastructure elements.

3.3.7.2. Strategies

The strategies for smart infrastructure include:

① Offering free Wi-Fi: Free public Wi-Fi leads to a more connected society and agile interactions between people and business. The number of smart cities distributing free Wi-Fi is surging as they can empower their communities with better services.
② Adopting data-driven approach: Smart infrastructure relies on the collection, analysis, and interpretation of data for more informed decision-making. Governments and private organizations must invest in data acquisition, storage, and analysis to improve decision-making.
③ Developing inter-operable systems: To achieve maximum efficiency, smart infrastructure systems should be interconnected and allow real-time data exchange. This requires standardization of protocols, hardware, and software interfaces across systems and vendors.
④ Leveraging advanced technology: Smart infrastructure systems must incorporate cutting-edge technologies such as AI, IoT, and blockchain to improve performance and optimize operations.

⑤ Ensuring cybersecurity: Smart infrastructure systems are highly vulnerable to cyberattacks, which can cause significant disruption and even physical damage. Strong cybersecurity measures are needed to prevent unauthorized access and protect critical infrastructure assets.

⑥ Embracing sustainability: Smart infrastructure should be designed to promote sustainability including reducing energy consumption, minimizing waste, and supporting renewable energy sources.

⑦ Engaging stakeholders: Effective smart infrastructure requires collaboration and engagement across multiple stakeholders including governments, businesses, academic institutions, and the public. All stakeholders should take part in the planning, design, and implementation of smart infrastructure.

3.3.8. Smart Governance

3.3.8.1. Direction

Smart governance in smart cities is the application of technology- and data-driven approaches to enhance the efficiency, transparency, and effectiveness of urban governance. It leverages digital solutions, data analytics, and civic engagement to improve decision-making processes, service delivery, and overall urban governance.

Smart governance emphasizes civic engagement by adding residents to decision-making processes and encouraging their active participation in shaping urban policy through technology. For the MDP, a smart governance system might prove unfeasible over the short term but can boost bottom-up development and build more resident-centric cities.

3.3.8.2. Smart Governance Strategies

Technology platforms facilitate public consultations, online voting, feedback mechanisms, and crowdsourcing initiatives to gather input from the community. The Seoul Metropolitan Government (SMG) offers incentives to encourage public participation in the formation of a smart city such as Citizen Lab projects, activity gallery, data activities and education, and seminar support. The core components of the smart government concept in the SMG are presented in [Figure 1-16]. This paper's proposed approach could be directly applied to the MDP area.

[Figure 1-16] Smart Government Components in Seoul

Source: Lee (2019).

4. Short-term Smart Project Recommendations for the Marine Drive Project

Recommendations for short-term smart projects were selected based on the key strategic area covered in section 3 reflecting the MDP's priorities, feasibility, budget constraints, and scope.

4.1. Smart Safety

4.1.1. CCTV

Closed-circuit TV (CCTV) is an economically feasible way to raise public safety, and many studies show that this method is effective in reducing public fear of crime (Kim & Park, 2022). Seoul has a combined 152,388 CCTVs installed, a seven-fold jump over the past 10 years, and all cameras and monitors are managed and operated by the SMG and 25 city districts. The most frequently installed public CCTV is a dome camera with 360-degree filming and three bullet cameras with relatively low construction difficulty (see Figure 1-18). The installation cost per unit is USD 20,000 but this depends on type of camera and combination.

As the volume of public CCTVs surged, inefficiency and overlapping investments occurred as each institution managed such cameras separately. So through CCTV integrated

control centers, monitoring of traffic, crime prevention, illegal parking management, and disasters were integrated and CCTV installation was preadjusted to prevent reckless and redundant investment. (Choi and Choi, 2019). The average cost of such a center is about USD 1 million based on information from 229 such centers in Korea.

[Figure 1-17] Purpose of CCTV Installation in Seoul

Source: Seoul Metropolitan Government (2021).

[Figure 1-18] Public CCTVs in Seoul

Source: Yonhap News.

The SMG has also set up CCTV control centers in the city's 25 autonomous districts as well as Seoul City Hall to raise the efficiency of public CCTV operations. The Smart Seoul CCTV Safety Center was also launched under the project "Building a Smart Seoul Stability Network" (see Figure 1-19). This center was completed in 2019 and information networks

with public institutions in Seoul were formed over two years. Based on linked information, the safety center develops and provides customized urban safety services for prevention services catering to elderly dementia patients, cultural property management, and women's "safe return" home apps (Ansimi). It plays a key role in securing the golden time for civil safety services by providing real-time information from CCTVs from the city's 25 districts to facilities for emergency medical services, firefighting, and disaster response.

An example from Korea can estimate the number of cameras needed for the MDP area as well as the combined cost of installation and management. Sokcho, Gangwon-do, is a seaside city like Accra with a densely urbanized area of 1,055 ha that serves as the city center, with 572 CCTVs in the area shown in [Figure 1-20], or 0.54 cameras per ha. Based on this simple calculation, an estimated 53 CCTVs are needed for the MDP (area of 98 ha). Though subject to conditions as mentioned earlier, this means a combined installation cost of USD 1.3 million based on a unit cost of USD 25,000.

[Figure 1-19] Smart Seoul CCTV Safety Center

[Construction period] Dec 2018– June 2019
[Location] 15th and 16th floors of the S-Flex Center Smartium.
–15th floor (588㎡): Control room, conference room, office, etc
–16th floor (128㎡): CCTV safety experience center

Source: Smart Seoul Portal.

[Figure 1-20] No. and Cost Estimates for MDP Area

Source: Authors.

4.1.2. Smart Pole (S-pole)

As many cities worldwide gradually adopt the smart city model, smart ICT is applied to streetlights and traffic signals to provide citywide services so that residents can feel a higher quality of life through smart services. The SMG has installed the smart pole S-pole, which combines smart city ICT such as public Wi-Fi, IoT, intelligent CCTV, and electric charging (see Figure 1-22). The S-pole standard model used by the city is a platform-type supporting infrastructure that allows a pole to cross-accept smart functions according to the surrounding road environment and purposes. Ten types of installation guidelines modify the configuration of S-poles according to the surrounding environment, leading to a huge range of costs. Specifically, the price tag is USD 8,000 to USD 25,000 per S-pole depending on a feature's configuration. For example, a road-type S-pole includes streetlights, road data boards, public Wi-Fi, CCTV, and urban data functions, while an alley-type S-pole has security lights, CCTV, public Wi-Fi, and emergency bell functions. The expected benefits of S-poles can be largely summarized into three categories.

The first is the building of integrated road facilities and cross-build smart devices and replacement of old facilities to reduce construction costs. Second, the proposal of 10 types of S-poles as practical standard models enables efficient expansion and construction throughout the city. Third, integration of road facilities complexly installed in daily spaces allows improvement of urban aesthetics and raises the city's overall capacity to adopt new technologies later.

[Figure 1-21] Seoul S-Poles

Source: Smart Seoul Portal

The SMG since 2021 has promoted functional enhancement of S-poles and installed them. It started with pilot projects at major tourist attractions and places needing better pedestrian environments such as elementary schools. As of 2022, the state of S-pole construction in Seoul is shown in <Table 1-4>. The goal is to replace all old streetlights.

<Table 1-4> Status of S-poles Construction

Year	No. of S-poles	Construction Details
2020	26	Construction of S-pole standard model in road environments as demonstration
2021	116	Construction of integrated safety S-pole in child protection areas around elementary schools
2022	148	Expanded construction of S-pole
	10	Construction of S-poles for upgrading ICT convergence such as EV charging & drone stations for verification
Total	300	

Source: Smart Seoul Portal (2022).

4.2. Smart Environment

4.2.1. IoT-based Air Quality Remote Management System

Air pollution is Ghana's top environmental hazard to public health and sixth overall factor (out of 19) for death; the problem in Accra is especially bad (WHO, 2020). As many cities have grown more urbanized and air pollution risen due to the rapid growth of cars in Korea, the dangers of fine dust are on the public's mind. As a result, people want to know the real-time concentration and severity of fine dust in their everyday spaces to stay healthy, and

daily interest in this has increased. In response, the SMG launched the Fine Dust Warning System in October 2013 to reduce fine dust based on accurate measurement of fine dust and minimize damage to public health. For this, the city has kept expanding air pollution measurement stations and set up an integrated information system and online platform to disseminate 24-hour data in real time.

The city tracks two types of particles: PM-10 or smaller fine particles and PM-2.5 or smaller ultrafine particles. The SMG is trying to reduce the emission of both types under the goal of reducing emissions 10% every year. Accordingly, the criteria for issuing warnings of dangerous concentrations of fine dust have been gradually raised. The forecast grades of fine particulate matter are categorized as "good" (0-30㎍/㎥), "moderate" (31-80㎍/㎥), "bad" (81-150㎍/㎥), and "very bad" (151㎍/㎥) or more. The grade for ultrafine particulate matter is categorized as "good" for 0-15㎍/㎥, "moderate" for 16-35㎍/㎥, "bad" for 36-75㎍/㎥, and "very bad" for 76㎍/㎥ or more.

The severity of ultrafine particulate matter has increased, so the criteria for forecast ratings have been continuously strengthened. Thus in 2021, the monitoring system was raised to the level of developed economies such as the US and Japan. Seoul residents can receive text messages about fine dust concentration according to forecast level as well as data on outdoor activities and daily routines according to fine dust concentration.

[Figure 1-22] Types of Fine Dust, Reduction Targets and Forecast Criteria

Source: Ministry of Environment.

Seoul's air pollution measurement stations were built across the city, automatically measuring pollutant concentrations in real time for public access. Since 1988, the stations

have been run and managed by the Seoul Institute of Health and Environment. Each of the city's 25 districts has a station, and another 15 are along general roads and median lanes, 11 in urban backgrounds to observe vertical and horizontal pollutant movement, and six in mobile measurement vehicles. The largest and longest-running measurement stations cost about USD 167,000 each to set up (see Figure 1-24).

In addition to this network, the city has installed additional IoT-based city data sensors (S-DOT) to meet higher public demand for more detailed air information. These sensors can measure city data in addition to fine dust, and the numbers have gradually increased in Seoul. Each sensor costs USD 1,200 including installation (see Figure 1-25). . After installation, USD 250 per unit per year is needed to maintain and manage them. Fine dust data from measurement stations and machines are collected in the database of the Seoul Air Environment Information System, which was launched in 2009. The DB consists of an air quality data website and analysis support system and an integrated air pollution prediction and warning management system. The collected data is analyzed and sent to the public through the official website and shared with administrative agencies. Since 2018, the city has run an advanced support system for air quality data including for air quality modeling and diagnostic evaluation as well as a comprehensive situation room for a more scientific and systematic response to air pollution issues.

[Figure 1-23] Types and Distribution of Fine Dust Measurement Stations

Source: Smart Seoul Portal.

The collected data is also used to provide customized services for the public. Real-time air quality information is presented through channels common in daily life such as air quality information bulletins, fine dust signal lights, and electronic billboards at subway stations and in front of bus stops. Moreover, fine dust information is shown through the

color of lights on N Seoul (formerly Namsan) Tower, a city landmark. Such data is also available online on internet search portals and public agency websites. Given easy access to information on fine dust, residents can assume an active and informed role in protecting health, and the city can set long-term goals to improve air quality and develop clearer and more effective policy to manage pollution sources and reduce emissions.

[Figure 1-24] S-DoT Sensors and Usage

Source: Smart Seoul Portal.

All the Korean examples cited here might not be needed by the MDP. Using a smaller number of IoT sensors could be enough to cover the MDP area.

4.3. Smart Mobility

4.3.1. Bike Sharing Program

Smart mobility covers a variety of technologies and services from individual to new transportation services. Personal transportation models are supplied through channels from public and private companies in many cities with the rise of the sharing economy (Kim et al., 2020). Since 2015, the SMG has run Ttareungi, a public bicycle rental program, to build infrastructure allowing residents to use bicycles anywhere and anytime to alleviate air pollution and traffic congestion. Bicycle rental stations are based on demand for usage and connection with public transit stations.

In 2021, the city had 2,523 bike rental stations with 37,500 bicycles. The SMG has continued to increase user convenience in the bicycle sharing program through new technologies.

Bicycle use has risen every year, especially during the COVID-19 pandemic, growing 24% in 2020 year on year and 35% in 2021. As of 2021, a third of Seoul residents were members of the shared bicycle program, and the bikes are widely used throughout the city and in daily life.

Membership, however, is not directly related to usage. The 2021 survey showed that people selected Ttareungi as the city's resident-friendly policy with the highest recognition and satisfaction (SMG's Transportation Office, 2021).

[Figure 1-25] No. of Ttareungi Members and Rentals by Year

Source: Seoul Metropolitan Government.

The following is a brief summary of the bicycle rental method. First, check if a bicycle can be rented nearby through a smartphone app. Second, select a payment option to use the bicycle (i.e., annual, monthly, or daily pass). Third, scan the QR code of the lock on the wheel of the desired bicycle and press the rental button on the app. Fourth, use a bike when unlocked. Finally, when the used bicycle is locked at a desired place, the app automatically returns it.

<Table 1-5> Ttareungi Service Budget

(Unit: thousand USD)

		2015	2016	2017	2018	2019	2020	2021	Total
Expenditures	Construction	800	2,070	11,995	5,943	8,273	8,372	21,900	59,359
	Operations	913	2,850	5,820	9,982	15,010	18,108	5,035	57,721
	Total	1,716	4,921	17,816	15,925	23,284	26,480	26,935	117,080
Income		N/A	745	2,407	4,275	7,542	9,860	6,441	31,272

Source: Seoul Metropolitan Government City Transportation Office (2021).

The annual budget for operating the bicycle sharing program is shown in <Table 1-4>. The SMG has increased its budget every year to add, operate, and manage bicycles. As of 2021, the program's budget was USD 27 million or USD 858 per bicycle, including the latter's cost. As seen in the table, the financing relies heavily on public support but the program's positive impact on urban environments, communities, and residents is clear. Residents in Seoul recognize public rental bicycles as a form of public transportation, and despite the high initial cost, service operations can be long term and reliable. The city is also planning to add e-bikes to Ttareungi.

<Table 1-6> Installation and Operating Costs of Ttareungi

Annual budget (inc. purchase cost)	USD 27 million
No. of bicycles	30,000
Input budget per unit (inc. purchase cost)	USD 858
Price per bicycle	USD 591
No. of users	7,820,000
No. of app subscribers	1,380,000
Monthly rental fee	USD 5.8

Source: Seoul Metropolitan Government City Transportation Office (2021).

4.3.2. Street Design Planning for Future Mobility

A serious problem in personal mobility services is the clash with conventional transportation modes and pedestrians. In Korea, these problems started when private companies entered the e-scooter rental market. E-scooter users have no separate lanes on roads, so they use pedestrian paths and vehicle roads depending on traffic. This not only risks collision with cars or pedestrians, but also reduces the satisfaction of e-scooter users. Another problem is parking. When private companies rolled out services without considering infrastructure such as dedicated parking lots, disorder ensued and e-scooters posed a threat to pedestrians. So many cities are reorganizing private roads for personal mobility modes.

[Figure 1-26] Examples of E-scooter Issues on Typical Roads

Source: Seoul Metropolitan Government.

The southern Seoul suburb of Suwon, Gyeonggi-do, designated a demonstration district in 2022 to improve the convenience of personal mobility users and mitigate problems. The city installed road facilities only for such users with a budget of USD 400,000 with three components: a related stand, floor indicator, and guide sign on a road. First, a rental office was set up to resolve the e-scooter parking problem, which threatened pedestrian convenience and harmed the city's beauty. This office not only facilitates the return and parking of e-scooters but also offers charging. The cost of installing a stand is USD 2,500 per unit. Second, personal mobility-only roads were built and floor lights installed along the road to allow users to move safely even at night. The lights help users move safely, especially at night. Finally, a guide sign was installed on the roads to prevent pedestrians from accidentally entering a personal mobility road and displays the speed limit for users.

[Figure 1-27] Case Study of Suwon's Demonstration Project

Source: Suwon Special City.

4.3.3. Parking Information System

Securing parking spaces at a city center is a difficult task. Since land is limited and expensive there, the SMG is trying to best utilize parking spaces through a myriad of ways. For example, it uses IoT-based cloud technologies to share private parking spaces. First, the city government developed a way to share on-street parking lots.

[Figure 1-28] IoT-based Cloud Integrated Smart Parking System

Source: Seoul Metropolitan Government.

If residents register with the system and grant permission for others to use their parking spaces, visitors can park there when the residents are not using them. To register the resident-priority parking lot as a shared space, additional kiosks, CCTVs, floor markings, and IoT sensors for fare settlement are needed (see Figure 1-29). A combined USD 240 is spent to install all the equipment supported by the SMG.

In addition, smart parking systems for off-street public parking lots need IoT sensors and kiosks for detecting parking vehicles, information boards on real-time parking status, and road markings. The cost is about USD 250 per parking space including installation. That of a kiosk varies by product but is generally USD 20,000.

Real-time data on parking spaces is delivered to the public through an app, through which people can check surrounding real-time parking spaces and connect with the navigation app to park at the parking lot requiring the least amount of time. In addition, the system monitors real-time parking spaces, collects parking data, and uses it to predict traffic patterns.

Second, smart parking technology is used at both public and private parking lots, especially at underground spaces. This parking information system (PIS) has three key components (see Figure 1-30): 1) small sensors on the top of lots indicating availability; 2) guide panels along the rows each showing the number of available parking lots; and 3) an entrance system that recognizes a vehicle's license plate information. Since the costs can vary depending on road and infrastructure conditions, those for installing facilities for real-time management systems inside underground parking lots are an estimated USD 17,000 to USD 25,000 per entrance and USD 210 per parking space for parking guidance system (based on ultrasound).

[Figure 1-29] Integrated Parking Guidance System for Private Parking Lots

Source: Smart City Korea, Yongin Special City.

4.4. Smart Living

4.4.1. Smart Bin

A smart bin is a solar-powered trash compactor and smart device for keeping the urban environment clean. Its advantage is waste reduction to up to an eighth of its original volume by utilizing solar power.

Its function can be summarized as follows. First, a smart bin uses an AI-based recognition system to identify waste quantity. Second, plastic and paper among classified trash are compressed to decrease volume and reduce the frequency of emptying. Third, the fill level sensor checks a full smart bin and notifies collectors. Finally, garbage-related data is automatically collected in a smart bin, which is transmitted and processed in real time in the cloud.

[Figure 1-30] Smart Bin Functions

Source: CleanCUBE (www.ecubelabs.com).

[Figure 1-31] Smart Bin Operations

Source: CleanCUBE (www.ecubelabs.com).

[Figure 1-32] Real-time Waste Management System

Source: CleanCUBE (www.ecubelabs.com).

Smart bins in Korea were installed on college campuses to reduce overall maintenance costs (see Figure 1-33). After replacing 400 trash bins with 144 smart ones, garbage disposal costs plummeted nearly 86%. One smart bin costs about USD 4,100 and the price range of each model varies depending on model and options.

[Figure 1-33] Smart Bin Applications

Source: CleanCUBE (www.ecubelabs.com).

4.4.2. Smart Bench

Smart benches are powered by solar energy and store energy to provide public services such as charging and Wi-Fi connections. Moreover, they can create a unique night view and provide a rest space for urban residents and tourists. Sensors attached to a smart bench provide real-time visitor and air quality data (see Figure 1-34). The data is used to understand surrounding areas and improve the travel experience. A typical smart bench costs about USD 2,750, though the price varies depending on model and options. For example, a smart pergola with a roof goes for about USD 4,200.

[Figure 1-34] Smart Bench Functions

Source: Authors.

[Figure 1-35] Examples of Smart Benches in Korea

Source: Authors.

4.5. Smart Datahub

4.5.1. Incheon Free Economic Zone's Smart City Platform – Cloud Data Center

Incheon has data centers to build a successful smart city. The Incheon Free Economic Zone's (IFEZ) Smart City Construction Project had three phases: infrastructure construction, system building, and service expansion. The first phase saw smart city infrastructure including devising a smart city construction strategy and communication infrastructure. The second designed the smart city operation center and services in detail and built the cloud data center. Finally, the third developed smart city platforms and new smart city services with IoT, big data skills and cloud technology. Among them, the cloud data center was the main smart city project in the second stage.

To effectively operate and manage its distributed IT services, the Incheon Metropolitan City Government promoted an integrated platform. The IFEZ Cloud Data Center is the first public software-defined data center (SDDC) to adopt virtualization technology. The center is managed and operated by Incheon U-City (Incheon Smart City), a public corporation owned by the city government. The center has three areas occupying 400㎡, 230㎡, and 240㎡ of space. By consolidating them through servers, networks, and storage virtualization, the center maximized spatial efficiency and is now on the third and fourth floors of Incheon G-Tower.

[Figure 1-36] Example of Data Centers in Korea

Source: IFEZ (2017).

The center was built under the IFEZ Smart City Construction (3S-Integrated) Strategy. The three strategies are 1) spatial integration of each smart city center in IFEZ's three districts into one facility; 2) cloud-based system integration of the three data centers into a cloud data venue (IFEZ hardware platform) for efficient use of ICT infrastructure resources; and 3) platform-based service integration used to build center equipment via the integrated design of each hardware and commercial software.

The center corresponding to the hardware platform is an SDDC that introduces virtualization technology and achieves PUE 1.5 energy efficiency with an enclosure rack system for energy efficiency. A combined 142 networks and security devices are used, including 51 types of virtual chassis backbone switches. Servers including 32 IBM P770s and other types total 65 units and storage equipment like 23 types of integrated video storage and others 175 units, which can store 1.2 petabytes of files.

Savings of USD 3.1 billion from the original budget were achieved by leveraging the devices used at the city's data centers. In the end, it cost USD 1.6 million to build the cloud data center. As mentioned earlier, this paper believes that this data center is not needed for the MDP considering the latter's scale, quantity, and data types. Using a CCTV control center or another on a smaller scale to manage CCTVs, IoT sensors, and other data types will be sufficient.

4.6. Smart Infrastructure

4.6.1. Public Wi-Fi

Public Wi-Fi is an effective infrastructure for governments to connect entire cities, allowing people to access information they need easily and quickly through their personal devices such as laptops, smartphones and tablet PCs. Free Wi-Fi at tourist spots also provide a pleasant visitor experience.

[Figure 1-37] Cost and Coverage of Public Wi-Fi

Source: Authors.

Korea's free public Wi-Fi infrastructure and services have expanded substantially over the years. They are found at public transportation hubs such as subway and bus stations and even main roads. In addition, the government is continuously improving the quality of public Wi-Fi. For example, it has installed Wi-Fi repeaters at reasonable cost and improved Wi-Fi quality like faster download speed and wider coverage through integration with urban infrastructure such as bus stops,. A download speed of 500Mbps is available in most of Seoul, allowing the streaming of HD video on 10 devices at the same time. Coverage by a Wi-Fi repeater is a radius of 30 meters. The cost of installing one at a bus stop is about USD 4,980 per unit and the maintenance expense is USD 27.5 per a month. Assuming that Wi-Fi is installed at all bus stops and on the beach (every 30 meters) in the MDP area, USD 298,800 is needed for installation and USD 1,650 for monthly maintenance (see Figure 1-38).

[Figure 1-38] Public Wi-Fi Installation Plan for MDP Area

Source: Authors.

4.6.2. 3D Screen

A 3D screen (digital signage) is a converged platform that uses digital technology to connect a network with a display screen installed at a public and commercial space to display and remotely manage images and information. The screen can even be a tourist attraction in a city.

In 2016, the SMG designated the area in and around Samseong Station on Seoul Subway Line 2 as free outdoor advertising zone and allowed 3D screen installation. In addition, the city has added many 3D screens downtown. Buildings with screens must show more than a certain percentage of public art content. “Wave” is a leading work of digital art using a 3D screen at Samseong Station, providing a visual feast for both residents and tourists.

Department stores also use 3D screens to attract tourists and residents. One example is the “Magical Holiday” display on the exterior wall of Shinsegae Department Store in Seoul. Shinsegae installed large media screens covering the exterior walls of its store during the Christmas season, consistently attracting many visitors and making the area a must-visit.

Hyundai Department Store also installed a large 3D screen the size of three basketball courts (37.4 x 36.1 meters) showing K-pop music videos, global weather data and forecasts, commercials for famous domestic and international brands, and art content from 6 a.m. to midnight daily. It consistently showcases media art matching each season to create a tourist landmark.

3D screens play an important role in city branding by creating the image of a tourist city, a highly effective way to change the reputation of a metropolis. The cost, however, is relatively high. The 3D screen on Hyundai (37.4 x 36.1 meters) cost over USD 9 million to install. The bigger the screen size, the higher the price.

[Figure 1-39] Examples of 3D Screens in Korea

Source: Shinsegae Department Store (2022), Hyundai Department Store (2022), d'strict (2020).

4.6.3. Interactive Floor Displays

An interactive floor display (IFD) consists of a projector and display with a built-in motion sensor that responds to human gestures and movements. The sensor detects user gestures and movement while the projector reacts with images and games. Such a display can create an interactive floor and wall and offer a touchscreen experience. Hardware kits are available for floors, walls, and bring-your-own-display digital signage. Visitors can also design their own systems. Friendly tools and flexible setup options make it easy to develop customized solutions at scale.

[Figure 1-40] Components of Interactive Floor Display

Source: LUMOplay.

An IFD is not only available to one user. Many people can participate in the event for an unforgettable experience, especially children.

At 7.6 by 3.6 meters in size, a media wall costs about USD 135,000 to build and USD 73,000 to produce interactive content for it. Similarly, the price rises according to the size of the wall. For the Children's Museum of the National Museum of Korea in Seoul, installation of the media wall and production of interactive content cost an estimated USD 567,000 (see Figure 1-41).

[Figure 1-41] Example of IFDs at Korean Children's Museum

Source: Official YouTube channel of Goyang Children's Museum (2022).

5. Conclusions

This project devised a comprehensive smart city plan for the MDP in Accra, Ghana. Based on literature review and the Korean experience, nine key strategic areas were identified as needed for the MDP: smart water, smart safety, smart environment, smart mobility, smart living, smart datahub, smart infrastructure, smart governance, and smart economy. Among them, this paper dealt with all of them except smart economy, which is covered in Topic 2 and provided short-term project recommendations for six strategic areas: smart safety, smart environment, smart mobility, smart living, smart datahub, and smart infrastructure. These were selected based on the priorities of the MDP, feasibility, and budget constraints. Total costs including installation and management costs for each recommendation were calculated based on the MDP plan to assist the Ghanaian government's progress. All recommendations are summarized in <Table 1-6>.

The most urgent investments for the MDP are CCTVs and a related control center, parking information system at the MDP central building, and public Wi-Fi. The estimated costs for these are USD 2.8 million. Investment for the rest might not be urgent so its cost was not estimated.

<Table 1-7> Short-term Recommendations for MDP and Costs

Areas	Short-term smart projects	Installation cost	Estimated cost for MDP
		Installation	
Smart safety	CCTV	USD 25,000 per unit (53 units)	USD 1,300,000
	CCTV control center	USD 1,000,000	USD 1,000,000
	Smart pole	USD 8,000 to USD 25,000 per unit	
Smart environment	IoT-based air quality remote mgmt. system	USD 167,000 for station, USD 1,200 for sensor	
Smart mobility	Bicycle sharing program	USD 591 per bicycle	
	Personal mobility stand	USD 2,500 per unit	
	Parking info system	USD 17,000 to USD 25,000 per entrance (e.g. 4 units) USD 210 per space (e.g. 500 units)	USD 200,000
Smart living	Smart bin	USD 4,100 per unit	
	Smart bench	USD 2,750 per unit	

<Table 1-7> Continued

Areas	Short-term smart projects	Installation cost	Estimated cost for MDP
		Installation	
	Smart pergola	USD 4,200 per unit	
Smart datahub	Cloud data center	USD 1,600,000	
Smart infrastructure	Public Wi-Fi	USD 4,980 per unit (60 units)	USD 300,000
	3D screen	USD 9,000,000	
	Media wall	USD 567,000	

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02

CHAPTER

Master Plan for Smart City ICT in the Marine Drive Project

Jong Kyu Lee (Institute for Future of State)

1. Introduction
2. Smart City and Digital Payment
3. Payment Systems in Ghana
4. Evaluation of the Mobile Money-dependent Payment System
5. Designing a Digital Payment System for the Marine Drive Project
6. Action Plans and Implications for the ICT Master Plan of the Marine Drive Project

Keywords
Smart City, Digital Payment, Mobile Money, Multi-channel Banking System, Financial Infrastructure, Payment Council, Digital Mining, Economic Development, Sub-Saharan Africa, Ghana

Master Plan for Smart City ICT in the Marine Drive Project

Jong Kyu Lee (Institute for Future of State)

Summary

This project under the 2022/23 KSP with Ghana was conducted with the title “Master Plan for Digital ICT in the MDP Area.” Different from the subject given in the title, the main purpose is to fulfill the request of the Ghanaian authority responsible for designing the MDP for strategies to build digital financial infrastructure in the MDP area.

A digital payment system cannot be built simply by installing a few devices with top-level technology; it requires reconciliation with the demand factor. And a payment and settlement system is not a concept confined to a certain region but applies to the entire country.

Given the difficulties of this topic, this report first surveys the theoretical and conceptual discussions on the relationship between the smart city and digital payment systems. The study concluded that the system is essential to enhance and/or complete the function of a smart city. This means that when devising an MDP plan, the need for a digital payment system in the MDP area should not be overlooked. In addition, this report through the survey created an approach to building a digital payment system in a smart city. Though a smart city is limited to a narrow region, use of a national perspective is rational to set up a digital payment system in a smart city.

Applying this approach, this report examines the payment system in Ghana and reviews the feasibility of its application to the MDP. The Ghanaian payment system is heavily reliant on mobile money (MM), which is widely used for simple remittances by rural residents and as a major payment instrument in the country. This has been confirmed by several statistics. In reality, Ghana since the 2000s has promoted digitization of the payment system for financial inclusion and economic development.

In the next stage, this report evaluates Ghana's mobile money (MM)-dependent payment system and explores its unsuitability to handle diversified demand for financial transactions frequently occurring in urban areas, especially in a smart city like the MDP. The report summarizes the limitations and disadvantages of the system such as limited effects on curbing cash use, unclear evidence of poverty alleviation and economic development, its incompatibility with an urban economy, cost inefficiency compared to a bank-led payment system, and adverse impact on the macroeconomy.

Considering the MM-reliant system's limitations and disadvantages, securing a new economic engine for Ghana through the MDP will be difficult if such a system is maintained. From this perspective, this report looks for an alternative appropriate for the MDP area and to spread it throughout the country.

The outline of an ideal payment system is summarized below in the table, which compares the new system with the one in use for better understanding.

<Table 2-1> Comparison of Payment System: Current vs. New

	Current system	New system
Payment instruments	✓ Mobile money	✓ Variety of instruments
Payment service provider	✓ Telcos	✓ banks
Main channel	✓ MM agents	✓ Multi-channel
Target groups	✓ Unbanked in rural area	✓ City dwellers with bank accounts
ICT infrastructure	✓ Wireless network	✓ Full sets of ICT infrastructure
Policy objectives	✓ Financial inclusion	✓ Economic development
Ecosystem	✓ Telco-centered	✓ Bank initiated
Network properties (Ⅰ)	✓ Closed network	✓ Open network
Network properties (Ⅱ)	✓ Self-independent network	✓ Shared (common) network
Participant relationship	✓ Exclusive	✓ Cooperative

Source: Author.

The essence of the new digital payment regime can be summarized as a multi-channel banking system equipped with payment instruments and channels freely available for use by customers according to situation. This report suggests strategies to build such a banking system under the smart city model for the MDP, especially a payment council acting as an executive decision-making body comprising financial institutions to induce the active participation of and cooperation among financial institutions essential for building and

running an efficient payment system. The digital payment system is not simply connection of the ICT systems of financial institutions but must meet the following prerequisites for seamless transactions between them: information processing procedures, dispute resolution rules, and ICT system that reflects these procedures and guidelines in software. These prerequisites are decided by mutual agreement by the participating financial institutions. In this respect, the digital payment system is like a shared network of participating financial institutions, with cooperation between institutions essential for smooth operation of the payment system. The Korean experience in setting up a payment council is attached to this report as an appendix in the final section. Finally, the conclusion presents guidelines for action by authorities, briefly mentioning how to design the ICT master plan for the MDP region along with a digital payment roadmap.

1. Introduction

Ghanaian authorities are considering the Marine Development Project (MDP) which seeks to develop the coastal area of the capital Accra into a smart city. In the process, they are trying to arrange the ICT infrastructure of the MDP area and build digital finance infrastructure, namely a digital payment system.

Designing an ICT master plan for the MDP area in a short paper is a monumental task because related infrastructure should be determined by demand factors such as smart city functions and specific types of payment instruments and/or channels, while the specific functions of the MDP have not been fleshed out yet.

Not only ICT infrastructure but also the digital payment system needs to run in harmony with demand factors. Their specific details are not determined solely by technological level but by demand situations as well as other circumstantial factors. For example, installing the most expensive and top-of-the-line technological system can be pointless if circumstantial factors are insufficiently developed to fully utilize the technology. So the most important task in designing a payment system or ICT infrastructure for the MDP area is identifying the proper technologies to meet demand. In other words, the design of the system and ICT infrastructure requires development of an appropriate mix of technical infrastructure and circumstantial factors.

The MDP's functions or types have yet to be specified, which will be the demand factor for the payment system and ICT infrastructure in the project's area. For example, it is unclear if the MDP will be developed as a residential or commercial area. Even if the

direction is toward a business area, will it be filled with commercial distribution facilities or will financial services be the main function? Accordingly, the MDP cannot specify demand that determines the technical level of ICT infrastructure or types of payment instruments and channels.

With these issues in mind, this report will seek to design a proper digital payment system, an essential infrastructure of a smart city like the MDP. Digital payment is a critical factor for the MDP; for the latter to reach the highest level of a smart city, it needs an efficient digital payment system. For this purpose, this paper first explores the relationship between smart cities and digital payment systems on a conceptual basis through survey of literature and case studies.

The next stage will cover Ghana's payment system focused on reviewing and evaluating if the system is suitable for the MDP. The country relies heavily on mobile money (MM) as a means of payment. This paper will describe the characteristics of the Ghanaian payment system based on statistics and comparison with Korea's case.

Afterwards, this report explores how the MM-dependent payment system is incompatible with a smart city. MM was invented for those with little to no access to modern banking in rural areas with no bank branches or automatic teller machines (ATMs). The MDP will see banks compete to open branches or install ATMs there. In addition, MM has its own limitations and inefficiencies and this paper will summarize its limits as a payment instrument from a general perspective.

The final section will recommend a suitable digital payment system for the MDP area based on a critical evaluation of Ghana's payment systems covered in the previous section. The so-called multi-channel banking system for the MDP area will greatly differ from the one in use, and this study will suggest strategies to develop the payment system, specifically the setup of a payment council as a driving force for implementing the multi-channel banking system in the MDP region. Comprising financial institutions such as banks, the council is the main decision-making body for building the multi-channel banking system in the MDP area.

The last step stresses the formation of a joint network between financial institutions as the key to building a digital payment system, which is not merely connection of the computer systems of financial institutions. Several prerequisites must be met for seamless transaction between institutions: information processing procedures, dispute resolution rules, and ICT system that reflects these procedures and guidelines in software. Moreover, building a multi-channel banking system requires these procedures and regulations, plus

facilities for each financial service. In this respect, this paper cannot stress enough how cooperation among financial institutions is essential for creating a digital payment system.

This study will not directly deal with the master plan for ICT infrastructure in the MDP area despite what its title. Instead, the suggestion is that this issue is handled by a steering organization, namely a payment council, which selects payment instruments and channels in the MDP area and decides on investment in related infrastructure.

2. Smart City and Digital Payment

This section discusses the relationship between a smart city and payment systems in a conceptual framework through a survey of literature on smart cities. Such systems previously were never mentioned in related discussions, but are now considered as an essential subject. This paper emphasizes that the system should be considered at the planning stage of a smart city. And the conclusion will recommend a perspective or approach to use in designing digital payment systems for the MDP area.

2.1. Early Discussions

A smart city plan seeks to improve quality of life for residents and achieve economic efficiency by applying information and communication technology (ICT) to urban infrastructure. In other words, the goal is digitization of urban facilities to solve problems caused by urbanization by connecting physical, social, and economic infrastructure with ICT (Harrison et al., 2010).

In the early years when the smart city concept first took hold between the late 1990s and the 2000s, the notion was not linked to digital payments. Early discussions were initiated by urban planners and/or ICT technicians from tech companies and emphasized the technological component as the key factor to the concept (Albino et al., 2015). At the time, the focus was simply on integration of ICT with physical infrastructure and efforts went toward properly managing urban infrastructure and improving urban functions and services through technology. This narrow viewpoint, however, prevented the technicians from paying attention to digital payments for reasons that remain unclear.

Other reasons explain the failure of smart cities and digital payments to align. First, while smart city was discussed by municipal entities, payment systems were a nationwide issue. Local government units designing smart cities were forced to exclude issues out of their

jurisdiction from discussion. Second, such talks in their early days were held in advanced economies with advanced payment systems, so there was no need to include the systems as a discussion topic when mentioning a smart city.

Cohen (2014), who presented an early concept of a smart city, also stressed the model's economic role but said nothing about payment systems in his discussion. His Smart City Wheel program presented in <Table 2-1> below describes smart city dimensions and corresponding issues. Ideally, digital payments should have been included in talks on a smart economy but were omitted from Cohen's program.

2.2. Recent Discussions

In the mid-2010s, however, digital payments emerged as an important theme in smart city discussions (Soe and Mikheeva, 2017). The empirical perspective began to recognize that a smart city could be completed only through its integration with digital payment systems. In a comparison of traffic flow and passenger convenience between smart transportation systems with and without automated fare collection (AFC), imagine how cumbersome paying transportation fares in cash is, as well as calculating and giving change; this drastically delays traffic flow. On the other hand, this problem is gone if the method of easy payment with smart or transportation cards is used. Integration of digital payment systems with smart mobility facilities will promote smooth traffic flow and raise public convenience.

<Table 2-2> Cohen's Smart City Wheel

Dimension	Working area
Smart economy	Local & global interconnections
	Productivity
	Entrepreneurship & innovation
Smart environment	Green buildings
	Green energy
	Green urban planning
Smart gov't	Enabling supply & demand policies
	Transparency & open data
	ICT & e-gov't
Smart living	Health
	Safety
	Cultures & well-being

<Table 2-2> Continued

Dimension	Working area
Smart mobility	Mixed modal access
	Clean transit options
	Integrated ICT
Smart people	21st-century education
	Inclusive society
	Embrace creativity

Source: Cohen (2014).

Reflecting this reality, the International Telecommunication Union (ITU) (2016) added a digital payment index to its indicators for evaluating smart city performance. In other words, not until 2016 did the ITU adopt digital payments as a key performance indicator (KPI) for smart sustainable cities. To elaborate, the ITU (2016) started to use the number of e-commerce transactions per 100 inhabitants through electronic and mobile payments to measure the size of e-commerce transactions in trade, a sub-sector of the smart economy.

In addition, select countries began to include digital payments as an important project in their smart city strategies. Hong Kong and Singapore, which have adopted the smart city at the national level, included digital payments as a major component of their smart city strategies. Since both are city-states, there was no need to distinguish between the central and local governments. The two areas are also highly dependent on intermediary trade between countries, making improvement of payment efficiency a necessary and important task from an economic perspective. In addition, the relatively underdeveloped digital payment system was caused by a strong preference for cash over deposits in financial institutions per traditional Chinese culture, a factor explaining why both cities had to modernize their payment systems.

The financial sector in the 2010s saw tremendous change due to ICT. Accepting these shifts is a national task for the world's leading economies. Hong Kong and Singapore are city-states vying for financial hub status in the region that embraced financial innovation by including digital payment systems in their smart city strategies. <Appendix 1> has more on related policy and smart city development strategies in both places.

Furthermore, major cities in countries with underdeveloped financial industries or payment systems from the 2010s began to pursue the smart city model. Thus these cities naturally sought to make digitization of payment systems a major task in the planning stage.

In conclusion, the global tendency is to recognize digital payment systems as an essential part of smart city strategy. The reasons can be summarized as follows. First, digital payments are a main element in designing smart cities. Urban infrastructure can be broadly categorized as physical, institutional, social, and economic. The need to streamline digital payment systems was eventually recognized as an essential task in digitizing urban economic infrastructure. As a consequence, digital transformation in this area tends to be considered a core task of smart city strategy.

Second, payment implies a kind of social overhead capital commonly applied to smart city functions. Most urban services such as transportation, water, environment, administration, energy, and healthcare are directly or indirectly related to digital payments. For example, the fees residents must pay to their municipal government are many: electricity, road tolls, public transportation, water and sewer services, school tuition, admission to major tourist attractions, public facility use, and fines. In addition, municipal governments are providing more financial assistance to residents like welfare for elderly people, subsidies, and scholarships. So digitizing payments is crucial to improve other functions of a city. In other words, the functions targeted for enhancement by the smart city model can be advanced through integration with digital payments.

Third, digital payment systems can serve as a major catalyst of digitalization of society through learning by doing or spillover effects since such systems are used by many. The learning effect of digital payment instruments is great in that the majority of the public uses them. And once the system is established, the speed of the spread of the effects is rapid and results of the policy are visibly confirmed in a short time. In the end, digitization of payment methods will spread smart technology, which in turn will promote digital transformation of society.

In summary, the smart city plan in recent years has included as a natural and necessary trend the improvement and expansion of digital payments corresponding to key urban functions. If a smart city is simply mechanically pursued at the level of the Internet of Things (IoT), it is difficult to say the goal was truly achieved. Since digitization of payment systems have its own importance as an element that further enhances and completes the overall functions of a smart city, digital payment systems are an essential factor.

2.3. Two Approaches to Digital Payments in a Smart City

Design of digital payment systems in smart city discussions covered two approaches. The first was a focus just on supporting smart city functions. For example, Octopus Card in Hong Kong and Oyster Card in London are the fruits of this approach. The second approach uses a national perspective while envisioning a smart city. Singapore's digital payment policy seems to follow this method, which led to the launch of a payment council.

The discovery of these two approaches was based on the author's intuition. Looking at the case studies of Hong Kong and Singapore, the approaches adopted by both were completely different. Refer to <Appendix 1> for more information.

After reviewing Ghana's payment system, this report will explore the application of these approaches to Ghana to design proper payment systems for the MDP area.

3. Payment Systems in Ghana

Ghana seeks to accelerate its digital transformation focused on finance. The country for a long time has strengthened its policy measures to develop digital payment systems. The history of its payment and settlement systems is summarized in <Appendix 3>.

An ambitious plan announced in 2008 sought to promote mobile money (MM). The Bank of Ghana (BoG) announced its Branchless Banking Guidelines 2008 to induce commercial banks to play an active role in spreading MM through partnerships with telecom companies (telcos). Consequently, MTN, Ghana's largest telco, in 2009 formed ties with nine banks to launch MM services. MTN invested heavily in expanding such services by sending agents to places with little or no banking services to educate residents there about and promote MM. But the guidelines failed due to complicated disincentives and the difficulty of meeting unattainable preconditions, like the need to register a valid national identification number.

Because of the less-than-expected result, the BoG immediately revised the guidelines. In 2015, it issued the Guidelines for E-Money Issuers and Agents as the revised version of the 2008 edition to grant telcos the opportunity to issue MM to customers without linking MM accounts to those of banks. The 2015 guidelines were so successful that MM is now the most common payment instrument in Ghana (Ifeanyi-Ajufo, 2022).

The 2015 guidelines were eventually incorporated into the Payment Systems Act 2019 (Act 987), which stipulates type of MM, transaction limits, permitted transaction types, customer identification procedures, telcos' obligations to secure capital and liquidity, and rules to protect consumers.

Consequently, MM is the dominant means of payment in Ghana because of such policy efforts. This will be explained through related statistics below.

MM is an electronic wallet service using a mobile or smartphone using electronic cash backed by an equivalent amount of notes and coins stored using the subscriber identification module (SIM) in a mobile phone as an identifier. Anyone can create an account on a SIM card. The MM account is usually provided by the payment service provider (PSP), which is a mobile network operator (MNOs). MNOs provide mobile infrastructure and an agent network. Anyone with an MM account can deposit cash into it for use in paying for goods, sending money, or withdrawing cash.

In Ghana, the National Communication Authority (NCA) regulates and oversees MNOs. Its agents facilitate cash-in, or converting cash into an electronic form of MM, and cash-out, or issuing cash from an MM account on demand. The agents are de facto liquidity managers in the MM sector. Fintech companies also provide a wide array of support services including mobile phone manufacturing, network equipment, and software.

Kenya's M-PESA is the origin of MM. "M" stands for mobile and "pesa" is the Swahili word for "money." By adding the function M-Shwari (shwari means "calm" in Swahili), M-PESA was expanded to provide loans.

MM has clear merit in providing financial services to households or social classes with limited or no access to financial institutions like banks. Reflecting this merit, MM is widely used in developing countries mainly for small person-to-person (P2P) transactions.

Ghana's smartphone penetration far exceeds its population. The country's 30 million population has 42 million smartphones. Meanwhile, the number of MM accounts is an estimated 48 million, exceeding that of smartphones but only around 18 million MM accounts, or about a third of the total, are actively used. The remaining 30 million MM accounts can be viewed as dormant.

An estimated 580,000 registered agents sell and distribute MM on the spot. Of these, about 440,000 conduct business activities. Considering that the country has about 20 million people over age 15, around 2% of Ghana's economically active population works as MM agents.

Between 2018 and 2021, MM penetration grew with the number of MM account registrations increasing 48% and that of active accounts 37%. Agent registration also saw high growth as the number of those active more than doubled.

<Table 2-3> MM-related Figures

	2018	2021
Total population (million)	29.6	30.8
No. of smartphones (million)	40.9	41.8
Registered MM accounts (million)	32.6	48.3
(active)	13.1	17.9
Registered agents	396,599	579,672
(active)	180,664	442,375

Source: BoG (2022).

The dominance of MM in Ghana as the No. 1 payment instrument follows a typical model in the developing world, where a low percentage of people hold bank accounts but dependence on MM is high. According to the World Bank (2022), 68% of the Ghanaian population aged 15 and over have an account at a financial institution or with MM. The remaining 32% is considered to use cash exclusively or not officially participate in economic activities. Only 39% of the population have accounts at a financial institution including a bank. In contrast, the proportion with MM accounts is 60%, meaning most people with accounts at financial institutions also have MM accounts. About 30% of Ghanaians aged 15 and over have accounts with a financial institution and MM. In conclusion, MM is the most common payment instrument used by the majority of the Ghanaian public.

In developed economies, most people have a bank account and use debit cards from such accounts as a major payment instrument. Credit cards are also an important payment form, but the share of use greatly varies by country. Developed economies do not favor MM accounts because of no incentives to use it attached to a smartphone since financial transactions are easily based in bank accounts.

<Table 2-4> International Comparison of Payment Instrument Types

(Unit: % of population over age 15)

	Population over age 15 (million)	Holding account					
			FI account	Credit card	Debit card	MM account	Able to use MM accounts
Sub-Saharan Africa[1)]	658.8	55.1	39.7	3.5	24.1	33.2	27.4
High income countries	1,016.6	96.4	96.4	57.4	86.1	-	-
Benin	7.0	48.6	23.8	1.4	5.4	36.7	33.5
Burkina Faso	11.6	36.1	21.1	2.7	8.9	24.7	19.6
Cameroon	15.4	51.7	23.5	1.6	7.3	42.4	43.4
Republic of Congo,	3.2	47.1	18.1	1.9	8.6	36.8	41.1
Cote d'Ivoire	15.4	50.8	20.6	2.3	7.9	40.4	37.6
Gabon	1.4	66.1	27.6	3.2	13.8	57.5	64.8
Ghana	**19.5**	**68.2**	**39.2**	**17.4**	**16.4**	**59.7**	**49.4**
Guinea	7.5	30.4	13.8	0.9	3.7	21.5	19.9
Liberia	3.0	51.6	28.6	3.5	7.6	36.3	21.5
Mali	10.7	43.5	28.4	6.0	13.4	29.4	15.7
Nigeria	116.5	45.3	45.1	1.6	35.3	8.7	
Senegal	9.6	56.0	28.1	4.8	11.6	44.9	34.5
Sierra Leone	4.8	28.8	13.8	0.5	1.4	19.0	14.1
Togo	4.9	49.6	24.9	1.5	7.0	36.5	30.5
Kenya	33.0	79.2	50.6	6.3	22.4	68.7	63.2
South Africa	42.2	85.4	84.1	10.0	58.9	36.6	25.8
Germany	71.6	100.0	100.0	56.5	94.0		
Japan	110.2	98.5	98.5	69.7	88.3		
Republic of Korea	45.3	98.7	98.7	68.4	84.0		
UK	55.3	99.8	99.8	62.1	95.5		
US	269.0	95.0	95.0	66.7	82.8		
China	1,153.8	88.7	88.7	37.9	75.8		
India	1,019.0	77.5	77.3	4.6	27.1	10.4	6.6
Hong Kong	6.5	97.8	97.8	71.6	88.1		
Singapore	5.0	97.5	97.2	41.7	93.5	30.6	22.2

Note: Excludes high income countries.
Source: World Bank (2022).

MM transaction volume in Ghana is far higher than that of any other payment instrument. As of 2021, MM trading volume reached 213% of nominal GDP, the highest for any instrument and over six times the combined transaction volume of all other instruments such as ATMs, internet banking, and debit cards. In addition, the growth rate of MM transaction volume was much higher than other payment methods. MM's trading volume

in 2021 jumped 3.4 times from that in 2018, far above the growth of other instruments. The surge in MM transactions over the same period was statistically consistent with the jump in MM account registrations and the doubling of MM agents as previously mentioned.

Yet internet banking grew eight-fold from 2018 to 2021 and mobile banking 3.6 times because both instruments surpass MM in efficiency and could eventually occupy a major presence among payment instruments. The surging use of these instruments is apparently due to their gradual adoption by the younger generation, who is accustomed to them, in addition to the effect of the lockdown during the COVID-19 pandemic.

<Table 2-5> Transactions in Ghana by Payment Instrument & Channel

(Unit: % change)

	2018 (A)	2021 (B)	(B/A)
Population (million)	29.6	30.8	
Nominal GDP (GHC, million)	308,587.4	459,130.9	48.8
LVP RTGS (GHC, million)	1,963,465.3	1,922,865.5	-2.1
(% of nominal GDP)	(636.3)	(418.8)	
Transactions via GhIPSS (GHC, million)	240,560.3	122,152.9	-49.2
(% of nominal GDP)	(78.0)	(26.6)	
CCC	203,465.3	20,384.0	-90.0
ACH DC	30,226.9	60,730.4	100.9
ACH DD	139.2	1,340.0	863.0
e-Zwich	5,651.1	7,913.8	40.0
GH-Link	543.7	427.3	-21.4
GhIPSS Instant Pay	534.0	31,357.4	5,771.7
MM (GHC, million)	223,207.2	978,323.8	338.3
(% of nominal GDP)	(72.3)	(213.1)	
Others (GHC, million)	64,286.4	176,469.5	174.5
(% of nominal GDP)	(20.8)	(38.4)	
ATM	21,796.5	35,687.4	63.7
POS	8,261.7	10,098.2	22.2
Internet banking	6,267.2	56,237.6	797.3
Mobile banking	5,658.4	26,112.3	361.5

<Table 2-5> Continued

	2018 (A)	2021 (B)	(B/A)
Debit cards	21,804.8	47,483.7	117.8
Credit cards	171.7	295.6	72.1
Prepaid cards	326.1	554.7	70.1

Source: Bank of Ghana (2022).

In Korea, the dominant payment instrument is account transfers like electronic funds transfer (EFT). The value of EFTs exceeds nominal GDP by an astounding 7,400%, while credit cards account for only 40%-50%. The use of prepaid cards or electronic wallet-type cash IC cards like MM is insignificant, implying rare use in Korea.

In payment scale, Ghana is considered to lag behind in development. Both large value payment (LVP) through the central bank account for only 400% of nominal GDP and retail payments through GhIPSS accounts 27%. These scales are quite small compared to Korea's. LVP transactional volume in Korea was 53 times (5,282.2%) nominal GDP, with the size of retail payments brokered by the Korea Financial Telecommunications & Clearings Institute, Korea's counterpart to the GhIPSS, 16 times (1,583.4%).

<Table 2-6> Korea's Payment Transaction Volume

(Unit: % of nominal GDP)

		1991	2000	2010	2015	2020	2021
System	LVP (Bank of Korea)	-	2,216.5	3,217.9	3,612.0	4,908.3	5,282.2
	Retail payments (KFTC)	2,517.0	1,379.3	1,262.1	1,232.5	1,428.7	1,583.4
Instrument	Bills & checks	2,497.6	1,042.1	649.5	342.7	234.0	227.2
	EFT	18.2	3,356.3	4,643.7	5,164.6	6,767.2	7,367.5
	Cards	4.7	20.8	41.4	45.2	50.3	51.3
	Credit cards	4.7	20.8	37.3	37.0	39.8	40.8
	Debit cards	-	-	0.0	0.0	0.0	0.0
	Check cards	-	-	3.9	8.1	10.2	10.2
	Prepaid cards	-	-	0.2	0.1	0.3	0.2
	Cash IC cards	-	-	-	0.0	0.0	0.1

Note: LVP means large value payments.
Source: Bank of Korea.

The penetration of the automatic teller machine (ATM), common digital payment channel, remains low in Ghana with just 2,278 ATMs installed nationwide as of 2021 or 11.4 per 100,000 people aged 15 or older (World Bank data). This is considerably lower than the average of 63 in member countries of the Organisation for Economic Co-operation and Development (OECD).

Korea, however, has one of the world's highest ATM penetration rates. As of 2021, the number of ATMs was 190 per 100,000 adults and that of cash dispensers (CDs) that offer part of ATM functions 62. As a result, the nation had 250 ATMs and CDs per 100,000 adults. In the early days, CDs dominated the market but the presence of ATMs with more functions has recently surged.

Several factors are behind the rapid spread of both machines in Korea. The KFTC completed a related operating platform in 1988. The CD/ATM network was built as a shared network among participating financial institutions based on procedures and regulations agreed by all participants. By 1992, all banks participated in this network to form the basis for the expansion of CD/ATM operations.

In addition, Korea since the early 1980s has pursued financial liberalization to create a competitive market environment for financial institutions. The favorable macroeconomic environment of the late 1980s caused wage hikes in every sector including finance. In response to these circumstantial changes and to reduce the wage burden, banks actively installed CDs and ATMs. Against this backdrop, financial institutions actively expanded related operations to offset higher wages amid intensifying competition.

Basically, CDs and ATMs guarantee customer convenience compared to using a financial institution. In general, the inconveniences or problems with the use of such institutions include the need to visit one and wait in line for services. In contrast, an ATM greatly reduced this problem. In the initial stage, higher demand for convenience expanded the networks for CD and ATM.

[Figure 2-1] No. of ATMs in Korea

(Unit: per 100,000 adults)

Source: Bank of Korea.

In the early 2000s, demand for CDs and ATM soared again due to the adoption of the five-day workweek. For customer convenience, ATMs were also installed other places like shopping malls or public places. In addition, competition intensified as ATM operators, not financial institutions, were allowed to install CDs and ATMs to earn commissions. In recent years, however, the spread of online and mobile banking has led to a decrease in CD and ATM volume due to plummeting operating revenue.

Ghana has promoted digital transformation in payment and settlement, fueling significant growth of MM. Nevertheless, studies show that the country still lacks an efficient payment and settlement system to support economic development, and the problem has reached a critical point given excessive dependence on MM. For example, a tax on MM transactions in 2022 was considered a setback for the country's payment and settlement system that could lead to further increases in cash payments.

4. Evaluation of the Mobile Money-dependent Payment System

This section covers the stage of evaluating MM as a payment method. Can heavy reliance on MM in lower middle-income countries like Ghana lead to economic growth over the long term? In other words, is MM efficient enough to support economic development compared to bank-centered payment systems? Is MM more efficient than bank-centered payment systems? More directly, can the MM-reliant payment system adequately support the MPD's smart city?

4.1. Favorable Mood for Mobile Money

The international community generally evaluates MM positively, and this was boosted by an article by Suri and Jack (2016), who surveyed households using M-Pesa in Kenya. They said about 200,000 people, or 2% of the Kenyan population, escaped poverty through MM. Manyika *et al*. (2016) also indirectly supported their argument by stressing the positive aspects of digital finance. Global society agreed with this notion including international financial institutions, public organizations in donor countries, and charity groups like the Bill & Melinda Gates Foundation. This trend is a syndrome-like phenomenon that spread widely worldwide amid the international drive to expand financial inclusion and alleviate poverty in developing economies.

MM has clear advantages of overcoming the limitations of a bank-centered payment system like provision of financial services to those who cannot open a bank account for reasons such as insufficient income. In this regard, the world and charity organizations in developed economies have strongly supported MM's spread to promote financial inclusion in the underdeveloped world, where many lack access to banking services and those from other financial institutions.

MM has spread to much of the world, used in 98 countries, 1.35 billion registered accounts, annual transactional volume of USD 1 trillion, and 5.6 million agents (GSMA 2022). The examples for MM include MTN in Uganda, Orange Money in Cote d'Ivoire, and Alipay and WeChat in China.

Yet to think that MM will alleviate the poverty of the low-income class and make a great contribution to a developing economy's development is delusional. Moreover, evaluation of MM as an efficient means of payment requires caution, as does arguing that MM can replace banks.

Remembering lessons learned from the past is crucial in this regard. After microfinance was introduced in the 1980s, the international community believed that new financial techniques could solve poverty in developing economies. The idea that poverty could be solved through micro-finance such as Gramin Bank has since remained popular. This belief has led to the launch of numerous microfinance organizations around the world. Back then, the tendency to positively view microfinance was considerably strong but the negative side effects have outweighed the positive benefits, something that has received little attention. For example, microfinance left the low-income class heavily indebted and many lenders accumulated wealth through financial corruption at the expense of the intended recipients.

According to Harring (2017), the case study of microfinance has been reborn as through the financial inclusion concept and consequently, MM has again grabbed the limelight as a means of such inclusion. Excessive praise for of MM will make it difficult to avoid encountering the same results as microfinance in the past. In short, MM simply cannot alleviate poverty of the low-income class and make a great contribution to a developing economy's development.

From this perspective, a more accurate assessment of MM is crucial rather than emphasizing only its positive aspects. This is especially true for Ghana, which seeks to promote digital payment systems for a new smart city in the MDP region since efficient payment systems in the area can decisively impact the future of Ghana's economic development.

4.2. Evaluations

Perspectives on the limitations, disadvantages, and negative aspects of MM are summarized below.

4.2.1. Limited Effect on Curbing Cash Use

A major reason for promoting digitization of Ghana's payment and settlement system is to reduce demand for cash. Ghanaian authorities also said in reports that they are pursuing digital finance to curb the use of cash. For example, a major objective of the country's payment and settlement policy is to reduce the use of cash, with the BoG saying its goal is "to discourage the use of cash for transactions while encouraging the use of non-paper-based instruments." In addition, the Ghanaian government in 2020 announced plans to promote the use of digital payment instruments in its Cash-Lite Roadmap.

In general, reduction of cash use is natural when the payment and settlement system is digitized. This has yet to occur in Ghana, however, despite promotion of digitization of payment instruments centered on MM.

Evidence is scarce to support the notion that higher MM penetration lowers cash use. In other words, MM has an extremely limited effect on reducing demand for hard currency. Use of MM in the form of a prepaid card incurs a limit to reducing demand for cash. Even users of MM need cash for the process of converting cash to MM, that is, in the step of charging MM to a SIM card by exchanging fiat money for e-money at agent locations. The tendency in Ghana is not to reduce cash dependence as a significant number of MM users reluctantly use

MM because of no bank account and high fees for MM transactions (Tay, 2020).

Despite MM's high growth in penetration in recent years, Ghana still heavily relies on cash. The cash holdings ratio (ratio of currency in circulation to broad money or M2) has moderately declined since the early 2000s, but this trend has stopped in recent years especially since 2018, when MM began to surge. The ratio is now around 20%, which is considered quite high and reflects how cash still occupies a significant portion as a form of payment despite the perception of MM as a dominant payment instrument.

The high cash holdings ratio is also confirmed by looking at the M2/nominal GDP ratio, which indicates financial deepening, or increases in a country's ratio of financial assets to GDP. Over the past 20 years, Ghana's M2/nominal GDP ratio has shown a fluctuation around the 20% level with no growth as depicted on the left side of [Figure 4-1], meaning Ghana has made no progress in financial deepening. This implies that Ghanaians prefer holding on to cash rather than depositing it at financial institutions. As discussed in <Appendix 2>, several factors are behind this phenomenon like repeated economic crises, high inflation, and lower real interest rates. In conclusion, the widespread use of MM in Ghana has not reduced the use of cash.

Korea had a similar experience in the 1960s and 1970s. In the latter decade, financial deepening was stagnant and dependence on cash stuck for a considerable time. When economic development began in the 1960s, the currency-to-M2 ratio plummeted while the M2/nominal GDP ratio surged. In the next decade, however, the expansion of the financial sector stagnated amid high inflation and price volatility and the decline in the currency-to-M2 ratio stopped. In the 1980s, financial deepening steadily recurred due to policy efforts toward macroeconomic stabilization including price stability and stimulation of people to open bank accounts, resulting in the accumulation of financial assets. Furthermore, payment instruments saw innovation like the adoption of credit cards. For reference, the currency-to-M2 ratio accounted for merely 4% in recent years and the M2/nominal GDP ratio exceeded far above 170%.

[Figure 2-2] Currency Ratios in Ghana and Korea

(Unit: %)

Source: Bank of Ghana and Bank of Korea.

4.2.2. Unclear Evidence for Poverty Alleviation & Economic Development

Digitization of the payment system or expansion of mobile money is intended to achieve financial inclusion by providing financial services to lower-income earners in rural areas with little to no access to traditional financial services. And the goal of expanding such inclusion is to alleviate poverty in the low-income group through such services.

History, however, has shown that the expansion of financial services to low-income groups cannot raise their incomes. One example is micro-finance (Haring, 2017), whose premise is to overcome poverty in developing economies, but this has not happened.

A similar logic can be applied to MM. Low-income earners' access to finance, in other words having a financial account, does not increase their incomes. Most countries have cases in which MM accounts are created but not used. Even Ghana has 48 million registered MM accounts but only 18 million are used actively. In conclusion, growth in the number of low-income earners' accounts, namely the rise in financial use by low-income classes, does not automatically reduce their poverty (IEG, 2016, p.ix).

Batemana et al. (2019) argued that MM's income-enhancing effect is not great. To an extent, MM users enjoy improved productivity and reduced working hours. Yet in rural areas with far smaller markets, a person who gains market share through productivity improvement means that of another person decreases. Batemana et al. (2019) said that because the efficiency gains of MM users lead to job or income losses for others, MM contributes little to economic development. In this zero-sum game, the productivity effect from MM is largely marginal for society.

Furthermore, broadening financial access is not necessarily desirable because of side effects like high indebtedness. An MM account can lead to excessive debt for users. Developed mainly for simple remittance, MM has recently expanded to offer small loans. The ease of lending has created borrowing problems for many users with weak financial discipline, with numerous cases of the borrowed money used for non-economic purposes such as gambling.

Considering the marginal increase in income of the lower-income class in rural areas, MM's contribution to economic development is seen as insignificant. While raising the earnings of the class in rural areas helps alleviate poverty, claiming that such increases promote economic development is a leap of logic because stimulating their economic activities has a marginal contribution to overall economic development.

4.2.3. Unsuitable for Urban Economy (or Smart City)

MM is unsuitable for urban areas, which have a wide array of transaction types that are frequently used. Even if MM use is inevitable in rural areas where banks have few to no branches, it is a mistake to think that MM can outperform banks in all regions or types of transactions. MM is not a major payment method for the high-income class in metropolitan areas, where banks are concentrated.

The reason for this can be thought of in various ways. In addition to inefficiency covered in the next section, other problems include the inconvenience of frequently charging MM on mobile phones. Moreover, it is virtually impossible to use MM for large-scale payments because of the daily or monthly limit as shown in <Table 4-1>. For example, why should a merchant who has moved into a shopping mall in the MDP area not have a monthly transaction amount of GHS 50,000 (about USD 5,000), the maximum monthly limit of an MM transaction?

The idea of using MM as the main means of payment in smart cities like the MDP is extremely flawed. Again, MM is specialized for simple transactions in rural areas, so the notion of applying it to a smart city overlooks that payment instruments each have their own optimal uses.

<Table 2-7> Limits on MM Transactions

(Unit: GHS)

Type	Daily limit	Monthly limit	Maximum balance
Minimum account	300	3,000	1,000
Medium account	2,000	20,000	10,000
Enhanced account	5.000	50,000	20,000

Source: Tay (2020).

A major reason MM cannot be used in urban areas is its lack of credit evaluation function. In urban areas, anonymous transactions with strangers frequently occur and for that, the credit status of the counterparty must be known. Since this is impossible between buyer and seller, a third party like a bank or credit rating bureau commonly checks the credit status in advance. In other words, banks exert positive externalities through their credit evaluation function. A bank's decision to make a loan or open a bank account means that a credit evaluation of the customer was done. MM, on the other hand, has a weak credit evaluation function and thus cannot exert a positive external effect, rendering it unsuitable for supporting transactions in urban areas where anonymous transactions are frequent. MM is of limited use when the transaction costs (impediments) of credit evaluation can be reduced without bank intervention.

4.2.4. Cost Inefficiency

When conducting financial transactions using MM, other fees are incurred in addition to the burden of maintaining a bank account. A commission is due at the stage of charging MM or withdrawing cash. In the case of MTN Ghana, 0.5% of the transaction amount is charged for a transaction of under 50 GHS and 1% for that above 50 GHS. Even if a user sends money directly through a smartphone, a similar rate of usage fee will result. In the case of paying public utility bills by MM, the fee is around 2% and much higher for remittance through an MM agent. Around 1% of the transaction amount is paid as commission or fee in Africa on average (Tay, 2020).

The additional costs of MM transactions can be better understood by describing the payment and settlement process. In general, the fund transfer transaction between sender and recipient is mediated with help from each party's bank that provided the account. The transaction is concluded through settlement between the banks. On the other hand, MM trading features another intermediary (agent) to provide this trading system for those with no bank accounts. Instead of using the account of the sender or recipient of the funds, MM can be viewed as using the agent's bank account.

<Table 2-8> Fees & Charges by MTN Ghana

(Unit: GHS, %)

Transaction type	Range	Fees & charges
Transfer service fee	up to 50	2.5
	exceeding 50	5
Transfer via mobile phone	up to 50	0.5
	exceeding 50	1
Withdrawal charges	up to 50	0.5
	exceeding 50	1

Source: Yen News, accessed on March 31, 2023. (https://yen.com.gh).

Eventually, an agent intervenes in the middle to charge new brokerage costs for an MM transaction. Financial transaction opportunities provided through agent intervention on behalf of those unable to access banks was once considered an MM advantage. Compared to financial transactions done without such intervention, commission for an agent is considered an expense. [Figure 2-3] and [Figure 2-4] compare the cost of additional engagement by intermediaries in simple fund transfers.

The main purpose of promoting digital transformation in finance is to reduce brokerage costs. For example, an ATM replaces a teller at a bank counter, offering financial services such as deposits, cash withdrawal, fund transfer, and remittance that cut costs. In many cases, the purpose of digital transformation in finance is to create a cashless society, but this fails to capture the essence of the transition. Reducing cash dependence is only secondary, and the larger goal of financial digital transformation is to reduce brokerage costs.

Factors like inconvenience other than direct pecuniary cost is also an important factor in MM transactions. Convenience is mentioned as an MM advantage, but many inconveniences are also unique to MM. A typical example is waiting because of the time needed for a MM transaction to be completed. In certain cases, an agent could run out of cash and fail to meet the demand of a customer to withdraw cash from an MM account. For whatever reason, the MM network might not operate smoothly, forcing customers to wait until it recovers and try again.

[Figure 2-3] Payment Transaction Types

Source: Author's own drawing.

[Figure 2-4] Payment Transactions (in case of MM)

Source: Author's own drawing.

The instability of the MM ecosystem poses another burden for users. A growing trend is to use e-wallets instead of cash-in, cash-out (CICO) transactions to avoid high fees. When a customer uses an e-wallet, remittance or payment is possible without commission and fees. More types of applications are helping to lower the cost burden of CICO transactions. This has caused agent incomes to plummet and drive people out of the industry. If the number of agents decreases, that of MM users could fall and render the ecosystem unstable.

The competition for market share among MM network operators (telcos) causes interoperability problems between MM networks, which often imposes a high burden on users. Most telcos charge higher transaction fees when customers transfer funds to another telecom network to encourage customers to remain on a company's network, but is instead slows transactions between networks. This is yet another cost for MM customers.

On the other hand, the interoperability problem reflects how MM is dependent on the closed network of telcos. Setting up a digital payment system requires changing closed networks of payment service providers including banks and telcos into open ones. The simple digitization of payment instruments should not be misunderstood as streamlining payment systems. From this perspective, it is difficult to consider MM to have the core elements of a digital payment system since it relies on a closed computer system. In other words, MM lacks an open network between and/or among payment service providers such as financial institutions and telcos.

4.2.5. Adverse Macroeconomic Consequences

For many developing economies like those in sub-Saharan Africa, they have no choice but to rely on capital from their developed counterparts to build digital transformation infrastructure due to lack of technology and capital. The governments of richer countries, charity organizations, and international developmental institutions support digitalization of the developing world to promote economic development there. As a result, most digital infrastructure in developing economies like telcos is established and operated by capital from richer countries. The result is a chronic issue. As digital transformation progresses in a developing economy, the profits of infrastructure companies increase and remits such gains to their home countries, resulting in a huge current account deficit for developing economies.

MM is also leading to the same result. Most major telcos providing MM services in many developing economies are foreign owned. Ghana's largest telco MTN is mainly owned by a South African company and the market's No. 2 player Vodafone is a British company. An average 1% of MM transaction volume is incorporated into telco revenue, so telcos earns huge profits from MM. A significant portion of the profits obtained this way goes to foreign shareholders and flow out to advanced economies.

Batemana *et al*. (2019) critically analyzed the case study of Safaricom in Kenya, concluding that MM leads to the outflow of national resources (p. 487). Safaricom is the operator of M-Pesa and registered on the Nairobi Stock Exchange, but its largest shareholder

is the UK-based Vodafone, which owns 40% of the company. The Kenyan government also owns a 35% stake, but most of the remaining 25% is owned by foreign nationals. Safaricom's profit in 2019 was USD 620 million. In addition, a bonus of USD 240 million was paid to shareholders, and a significant portion of these profits and bonus left Kenya. The company's share price also skyrocketed 600% between 2013 and 2018, so the value of shareholder assets shot up.

In 2018, the Kenyan government imposed a 2% tax on all MM transactions to prevent Safaricom from earning huge profits. The tax collected through this decision reached USD 270 million, equivalent to three years of national health insurance premiums.

M-Pesa thus became a vehicle for the rich abroad to earn huge profits from fees paid by poor people in the developing world. The outflow of national wealth reduced opportunities for economic development and denied a living wage for lower-income earners (Batemana, 2019). Digital finance and MM started with good intentions of helping those weak in finance, but the result was exploitation of the poor.

Based on this critical analysis, Batemana *et al*. (2019) called MM a source of "digital mining," a term used to explain how companies from richer countries extort profits from poorer states in the digital sector not unlike the past, when mines were mainly used by advanced economies to expropriate the property of their colonies.

A similar phenomenon is observed in Ghana. The country has experienced severe difficulties due to its huge deficit in balance of payments and lack of foreign currency reserves. Balance-of-payments statistics said net primary income outflow exceeded USD 4 billion per year on average with a current account deficit of USD 2 billion from 2018 to 2020. A significant part of this is likely to be remittance of profits from telcos due to active use of MM.

MTN, Ghana's top telco, has enjoyed jumps in profit and dividends in recent years, with after-tax revenue surging from GHS 324 million in 2012 to GHS 2 billion in 2021, nearly triple the GHS 755 million in 2018.

As a result, the payout of dividends grew from GHS 157 million in 2012 to GHS 983 million in 2021.When converted into USD, the rate of increase slowed as the GHS against the USD has continuously risen and the devaluation rate has accelerated recently.

Even so, MTN's profit dividends recently exceeded USD 100 million per year, and the spread of MM transactions is worsening Ghana's balance of payments and causing an imbalance in the external sector. In other words, the pro-MM system is deteriorating the country's balance of payments.

[Figure 2-5] MTN's Balance of Payments & Dividends

(Unit: Billion USD, Million GHS & Milllion USD))

Source: Bank of Ghana.
MTN financial reports (various years).

5. Designing a Digital Payment System for the Marine Drive Project

Considering its problems and limitations, the MM-reliant payment system will prevent Ghana from advancing its economic development through the MDP. This section is on how the country can develop its payment systems while promoting the MDP.

5.1. Two Approaches to Payment Systems for the Marine Drive Project

The end of Section 2 mentioned two ways to design payment systems suitable for a smart city like the MDP. The first is to apply a relatively narrow perspective by designing the payment system focused solely on the MDP. The other is that given the MDP's status as a project of national importance, a broader perspective focused on the country is needed when applying the design.

The first approach is to anticipate the MDP's functions and activities to be developed in the smart city and design payment systems accordingly. The specifics of the MDP have not been made public but are clearly expected to have more diverse functions than the capital. The MDP is expected to have high-end residential buildings, financial center, commercial facilities, and attractive tourist spots. When designing a payment system suitable for this, a range of financial transactions must be considered. As Ghana's payment system is heavily dependent on MM, the system is inadequate to fully support the MDP's functions. So even if the focus is on the MDP, a new system must be considered with an array of payment instruments and channels for appropriate use in accordance with financial transactions. The system should allow users to freely select a payment method depending on their situations while offering more payment instruments than just one or two.

In addition, the promotion of a smart city for the MDP can offer an opportunity to promote reform of the payment system at the national level. The envisioned MDP is geographically confined to a very narrow area but can also be seen as a national project. If the MDP succeeds, its spillover effects will spread like wildfire throughout the country as an opportunity to spur economic development. In this respect, the system designed for the MDP is highly likely to be applied nationwide. So an approach that considers the country while considering payment systems suitable for the MDP is needed to enable consideration of ways to extensively supplement the limits and problems of Ghana's payment systems. Even if applied, the new systems will have more diverse payment instruments and channels that will look quite different from those of an MM-dependent payment system.

No matter the approach, the direction is expected to remain the same. In other words, both approaches will remove the MM-centric system and provide more payment options and channels.

In this respect, this report favors the second approach. Though seeking a payment system suitable for the MDP, this report bears in mind a strategy to set up a payment and settlement system that will spread throughout the country. This approach seems reasonable in that checking for all possible problems by applying the widest perspective and devising a strategy that considers them reduces the risk of having to revise policy direction later.

5.2. The MDP as a National Project

The MDP seeks to implement a smart city in a narrow area of the capital Accra, but its vision is not limited to one city but covers the entire country. The MDP is likely to serve as a new catalyst for economic development since Ghana needs a new growth engine in its stage of economic development. Its economy has reached its limit based on reliance on the extraction and export of natural resources. With the underdevelopment of the service industry, huge outflows of national wealth through infrastructure dominated by foreign capital comprise a factor that further impedes Ghana's economic development. If digital transformation and development of the service sector and tourism are achieved through the MDP, the Ghanaian economy is expected to take off.

Considering that the MDP might be treated as a national project, construction of the core infrastructure necessary for the country in the MDP area is natural. In this respect, further development of Ghana's payment system along with promotion of the MDP is essential both for the latter's success and Ghana's economic development.

Payment systems are treated as an important part of national infrastructure. An efficient system is a key infrastructure in finance, and without it, financial stability is impossible and makes economic growth difficult to expect (BIS, 2012). A modern payment system and continuous improvements of its function are an important policy challenge facing all countries. BIS and IOSC (2012), which presents the basic principles of financial market infrastructure (FMI), said such infrastructure needs an efficient payment system.

> *FMIs play a critical role in the financial system and the broader economy ... the term FMI refers to systemically important payment systems, . . . These infrastructures facilitate the clearing, settlement, and recording of monetary and other financial transactions, . . . While safe and efficient FMIs contribute to maintaining and promoting*

financial stability and economic growth, FMIs also concentrate risk. If not properly managed, FMIs can be sources of financial shocks such as liquidity dislocations and credit losses, or a major channel through which these shocks are transmitted across domestic and international financial markets (BIS and IOSC, 2012).

Simultaneous promotion of payment system modernization while promoting the MDP is advised. Ghana's MM-dependent payment system must be upgraded into a more efficient system with the promotion of the MDP. The MDP offers a good opportunity for upgrading Ghana's system from several points of view.

5.3. Strategies for Payment System Development

The following section covers measures necessary to build a payment system suitable for a smart city in the MDP, while considering the limits of the MM-reliant payment system. Before going into detail, the outline of a proper system is summarized in <Table 2-9> below, which compares the new system with the one in use.

<Table 2-9> Comparison of Payment Systems: Current vs. New

	Current	New
Payment instruments	✓ Mobile money	✓ Range of instruments
Payment service provider	✓ Telcos	✓ Banks
Main channel	✓ MM agents	✓ Multi-channel
Target groups	✓ Unbanked in rural area	✓ City dwellers with bank accounts
ICT infrastructure	✓ Wireless network	✓ Full ICT infrastructure
Policy objectives	✓ Financial inclusion	✓ Economic development
Ecosystem	✓ Telco centered	✓ Bank initiated
Network properties (Ⅰ)	✓ Closed network	✓ Open network
Network properties (Ⅱ)	✓ Self-independent network	✓ Shared (common) network
Participant relationship	✓ Exclusive	✓ Cooperative

Source: Author's own.

5.3.1. Resetting Payment Policy Targets

Should financial inclusion continue as a top priority in payment system policy, something Ghana has made a key policy goal? Expansion of financial inclusion was the purpose for the strong recommendation of MM in Ghana. Considering that the prevalence of MM has reached a significant level, a shift in policy direction is urgent.

In general, the goal of payment system policy must be economic development. Even if financial inclusion is not excluded from the goal at this stage, too much focus on it is not advised. A common pursuit is efficiency of the payment system as an instrumental step toward the goal of economic development, a task that should be pursued on several levels.

First, development of the payment system has prerequisites. Fortunately, Ghana has seen much progress recently in establishing institutional and administrative conditions like the assignment of a personal ID number (PIN) by biometric information. In addition, technological conditions have improved due to the wide application of ICT and spread of fintech. Nevertheless, a significant number of people do not have PINs, so continuous efforts are needed to improve institutional conditions.

Next, efficient payment instruments are a must, with a variety of instruments and channels the key to achieving this goal. Depending on situation, the consumer should have the option to choose an efficient instrument appropriately and freely, a major point emphasized in this report. With a range of instruments provided, a gradual increase in the use of more efficient payment instruments is a must like expanded use of internet and mobile banking. Ghana has witnessed a positive movement in this sense given its surge of transaction volume through internet and mobile banking in recent years.

As a final point, demand-side measures such as financial deepening and stimulation of economic activity should go hand in hand with improving the efficiency of the payment and settlement system. Economic revival requires aggressive implementation of industrial policy to promote manufacturing and service industries. The promotion of the MDP as an industrial policy is expected to create new type of demand. Financial deepening, or quantitative growth in finance, is also essential for efficiency of the payment system. To this end, macroeconomic stability such as steady economic growth, lower inflation, and external equilibrium as well as credibility of financial institutions are required.

In conclusion, efficiency of the payment system is possible only when economies of scale are realized through expanded demand for efficient payment instruments as well as instruments provided in an appropriate manner. Revision of the policy target is strongly recommended to form efficient payment systems that directly support economic growth in the wake of the MPD's promotion, a new and innovative development strategy for Ghana.

5.3.2. Strengthening Banks' Role

The pattern of demand for payment services in the MDP area will greatly differ from the one in use. Large-scale fund transactions are expected to periodically occur among entities in commerce and industry, completely different from the pattern of small-scale simple remittance transactions. With more foreign visitors to come frequently, demand for payment services is likely to expand beyond Ghana. Considering changing payment demand, a variety of bank-centered payment services is needed instead of MM from telcos.

In the past, Ghanaian banks were relatively negligent in their improvement of payment and settlement services, adopting a passive strategy such as securing profit in areas where stable earnings were guaranteed mainly through loans to the construction industry. This passive management strategy resulted in a dominant position for telcos in payment services.

In 2015, with the Guidelines for E-Money Issuers and Agent Guidelines, telcos obtained dedicated electronic money issuer (DEMI) qualifications and entered the MM sector. Banks, however, received an opportunity through the Branchless Banking Guidelines in 2008 but responded passively.

The most crucial element in the establishment of an efficient payment system is voluntary bank participation. Banks play a key role in the payment and settlement process. Payment systems suitable for MDP are those typically seen in advanced economies in which banks are the main players. To set up such systems, voluntary and active participation of commercial banks is critical.

With the expansion of MM distribution, banks have turned the payment ecosystem into something in which they can actively participate (Creemers et al. 2020). Through digital payment platforms formed with the spread of MM, banks gradually increased their exposure to mobile banking. More identification methods were developed and incomes overall grew, greatly easing the constraints on bank account opening. The role of banks is gradually growing on the demand side of payment. Customers who get acquainted with digital finance request a higher level of financial services other than simple remittances, and will eventually look forward to comprehensive financial services. This makes it inevitable for banks to expand their roles to meet this demand. Creemers et al. (2020) concluded that the supply conditions for banking services have improved and demand factors strengthened through the spread of MM, creating an environment for banks to promote new businesses in payment-related services.

Ghana has seen similar trends. The KSP research team's visit there and meetings with responsible authorities confirmed that the attitude of Ghanaian banks has changed. In recent years, banks have gone from a conservative position focusing on traditional businesses such as loans to aggressively boosting and expanding their roles in payment and settlement operations.

The success of policy measures to raise efficiency of the payment and settlement system is determined by the response and participation of banks. This study proposes that Ghana's policy authorities develop a new mechanism to induce change by domestic banks. Forming a strong ecosystem leadership for payment systems is a critical opportunity to gain momentum for continued economic development.

5.3.3. Setting Up a Multi-channel Banking System

Predicting payment service demand in the MDP area is difficult since the specific activities and functions of the MDP remain unknown. Under these circumstances, another challenge is to design a payment system suitable for the MPD. To overcome this obstacle, the experiences of developed economies with frequent transactions through range of forms provide a good reference.

An MDP can be expected to perform similar functions of cities in richer countries as it pursues the smart city model. Referring to the experiences of richer states, one thing is clear: the MDP area needs a wider variety of payment instruments and channels.

In general, a payment and settlement system is formed by supply and demand. Demand for the payment system, or the purpose and intention of using one, is diverse. A key point of payment policy is to provide suitable payment instruments and channels in response to diverse demands.

Depending on the nature of the economy and society, demand for payments will vary. For example, a developing economy with large informal sectors predominantly has cash transactions, while a more developed one with a large business sector might need a modernized and digitized payment system (Cooper et al., 2018, p. 4).

A payment system equipped with payment instruments and corresponding channels is called multi-channel banking (Pavlovski 2013). In the real economy, a range of types of electronic means has been widely used in recent years as well as traditional instruments such as cash, checks, and bills. As for electronic means, electronic funds transfer and debit

cards are used in connection with bank deposits. Credit and prepaid cards and electronic wallets can also be used separately from deposits.

<Table 2-10> Payment Instruments & Channels: Illustration

	Instrument	Channel
Traditional	‣ Cash	‣ Branch, counter, teller
	‣ Check	‣ Post office
	‣ Bill	‣ Representative, agent
Digital	‣ Card	‣ CD/ATM ‣ POS
	‣ Phone	‣ Call center ‣ Interactive voice response
	‣ Internet	‣ Computers, email, online chat
	‣ Smartphone	‣ Wireless devices, QR code
	‣ eWallet	‣ App. APIs ‣ RFID/NFC
Future	‣ Cars	‣ SOA, TOGAF, BIAN, NLU/NLP
	‣ TV	
	‣ Home banking	
	‣ Wrist devices	
	‣ Eyewear	
	‣ AR gadgets	

Notes: CD: cash dispenser
ATM: automated teller machine
IVR: interactive voice response
RFID/NFC: radio frequency identification/ near field computing
SOA: service-oriented architecture
TOGAF: open group architecture framework
BIAN: banking industry architecture networks (based on SOA)
NLU/NLP: natural language understanding/processing
Source: Pavlovski (2013) and others.

Looking at channels where payment instruments are used, some accept certain instruments exclusively while others allow more. The growing diversity of instruments has also made channels more diverse. A bank teller or counter is a traditional channel. With the development of e-finance, the use of bank counters has decreased while that of other channels has gradually expanded. CDs and ATMs, computers, landline and mobile phones, POS, and QR codes are also forms of electronic financial channels as well as call centers, IVR systems, and email.

Payment instruments and channels are likely to undergo more diversification with the advent of technology (Pavlovski 2013). For example, a channel dedicated to cars is highly likely to emerge as a major payment channel, as are payment methods using TV and wearable devices such as eyewear and wrist gadgets. In the distant future, payment through virtual reality devices is also expected.

An example of the structure of a multi-channel banking system is shown in <Figure 2-6>, displaying how the system is built for each payment service. The critical issue is the difficulty of securing enough channels corresponding to the diversity of payment instruments. Though not properly displayed in <Figure 2-6>, another support system is needed in the process of collecting and delivering information from payment methods and channels, or so-called back-end processing that includes distribution networks and gateways. Refer to Pavlovski (2013) for details on backend facilities for payment services.

To fully equip the channels, each must have its own technological infrastructure, no problem in exchanging information with other systems, and high acceptance of future technologies. In addition, system stability is also an important consideration in designing the system.

Another point is that the multi-channel banking system is not the final stage of development of a payment system. Such a system could be the foundation for payment systems to move to the next level. Ghana is pursuing omni-channel banking to allow most payment and settlement services even through the use of a single payment instrument and channel. What makes this trend possible is the fintech revolution. If Ghana builds a multi-channel banking system, it can enjoy the benefits of the latest fintech more directly.

[Figure 2-6] Multi-channel Banking System

Source: BIS & IOSC (2012) (revised).

5.3.4. Ensuring Cooperation of Financial Institutions (or PSPs)

To build an efficient payment system, reconsideration of the nature of a modern digital payment system is needed. Another important point is that digital payment systems are an alliance of participating financial institutions. An e- or digital payment system in the modern concept means that the computer system of each financial institution is connected to those of its counterparts. The connection is not a simple physical link but set according to pre-determined procedures or rules to remove restrictions on information exchange or transfer and fund receipt. In practice, the procedures and rules are determined by agreement by participating financial institutions.

[FIgure 2-7] illustrates the components of digital payment systems including procedures, rules, and ICT systems in addition to payment instruments. In this respect, the system is like a shared network of participating financial institutions. For an entity to join the system

implies that its computer network is open to the outside world, a kind of club of participating financial institutions (BIS, 2012).

[Figure 2-7] Components of Digital Payment System

Source: Author.

A third party like the central bank or government can determine the procedures, but financial institutions should make decisions to ensure maximum efficiency. The parties must also consult each other and decide the rules for resolving disputed issues.

In the meantime, these procedures and rules are subject to change depending on the types of payment instruments or financial services. In addition, the ICT system needs to be defined in connection with these procedures or rules, which are generally reflected in ICT software. Thus the design of the ICT system is usually determined in connection with payment instruments and services.

In conclusion, cooperation between participating financial institutions is essential for smooth operations of a payment system (BIS and IOSC, 2012, pp. 38–39). The reasons include the reduced burden on individual financial institutions by jointly sharing the investment costs to establish a payment and settlement system. Demand for the payment system should be expanded as several financial institutions participate at the same time. Cooperation and participation by many such institutions can reduce the interoperability problem. Promotion of innovation is also relatively easily based on cooperation of financial institutions. The participation and cooperation of many institutions are essential for realizing economies of scope as well as those of scale.

5.3.5. Reorganizing Policy Governance Structure

Building an efficient payment system is never easy from a technical perspective. One requirement is to induce the participation and cooperation of financial institutions, especially commercial banks. To overcome these limitations and raise policy efficacy, this study proposes that Ghana reshuffle its structure of payment policy governance.

The previous sections briefly mentioned that a new policy structure could be needed to induce bank participation and cooperation. This section explores policy to tackle technical issues as well as encourage bank participation in payment-related businesses and cooperation among participating financial institutions.

The BoG's plan seeks to improve governance of the Ghana Interbank Payment and Settlement Systems Limited (GhIPSS) in its Payment System Strategy (2019–2024) including raising capital of GhIPSS and allowing it to pursue profit. The intent is to induce more participation by financial institutions in payment-related businesses.

Improvement of GhIPSS governance alone, however, is considered insufficient to form an efficient payment system for the MDP and ICT infrastructure across the country. Even with the MDP, it is far from easy to predict demand for payment services. But to have a multi-channel banking system in the MDP area, banks must invest in facilities in a short period of time. In other words, serious problems will arise in which decisions on large-scale investments must be made immediately amid an uncertain situation, making it difficult for GhIPSS, which will be permitted to pursue profit, to coordinate the interests of financial institutions.

Ghana has two consultative bodies for the operation of the payment and settlement system as described in <Table 2-11>. One is the Payment Systems Advisory Committee chaired by the BoG governor and the other the Payment System Council (PSC), which advises the decisions of the central bank's payment department at a more practical level. The PSC is assisted by four working groups in standards, automation and technology, operations, and pricing and legal affairs.

Both organizations comprise eight to nine members from almost the same institutions including government ministries, but financial institutions like banks are excluded. The stances and opinions of banks are transferred possibly only through the bank association, which is a member of these organizations. The committee and council apparently have the character of a policymaking body rather than an executive authority.

Based on the logic mentioned in the previous sections, this study proposes the organization and operation of a new decision-making body at the practical level, a payment council with strong motives and impetus to pursue investment in infrastructure for payment and settlement services. Instead of government ministries as regulatory authorities, this council should have banks and telcos as investors and members to serve as a decision-making body to design procedures for exchanging information on and transactions of funds, devise rules, and execute investment. This body will also supervise installing and operating infrastructure jointly established by financial institutions and coordinate interests that arise in the process of setting up and/or operating a payment and settlement system.

<Table 2-11> Consultative Bodies on Payment Policy

	Payments Systems Council (PSC)	Payment Systems Advisory Committee
Date	January 10, 2017	March 5, 2020
Legal basis	(NA)	Payment Systems & Services Act of 2019
Roles	Advise BoG's Payment Dept.	Advise BoG on payment policy
Chair	BoG deputy governor	BoG governor
Members	Ministry of Finance	Ministry of Finance
	Ghana Revenue Authority	GhIPPS
	Controller/Accountant General's Dept.	Securities & Exchange Commission
	Chamber of Telecommunications	Chamber of Telecommunications
	Ass'n of Bankers	Ass'n of Bankers
	Nat'l Insurance Commission	Nat'l Information Technology Agency
	Nat'l Communications Authority	Ass'n of Ghana Industries
	State Enterprises Commission	

Source: GBN (2017) and Entsie (2020).

Compared to other councils, the proposed payment council is far more similar to the PSC as it has working groups as subcommittees and makes final decisions based on their suggestions. The differences include the main members being initially composed of the central bank, banks, and telcos, replacing representatives of government departments or other organizations in the PSC. If limited to setting up a payment and settlement system for the MDP, the person in charge of the MDP can participate and express an opinion in this body. This study proposes upgrading the decision-making body from the level of a central bank department to the role of coordinator of the interests of financial institutions.

Ideally, the payment council should be chaired by the BoG governor and represented by top management of financial institutions as members. Because of many banks in Ghana, however, the number of committee members could be too large. To avoid this problem, methods are needed to divide banks into several groups and have their representatives attend as members. Within the group, one institution serves as the representative for a certain period under a rotating system.

Several working-level subcommittees are under this committee to review the businesses to be introduced and feasibility of the technology to be applied. The PSC follows this work process so Ghana will have no difficulty in applying this procedure.

The Korean experience of operating a payment council is summarized in <Appendix 4>. Korea in the early 1990s had major success in setting up a multi-channel banking system in a relatively short period thanks to the council. In this respect, this experience is considered extremely useful for Ghana, which needs a multi-channel banking system. Details are available in <Appendix 4>.

Finally, the launch of an ICT master plan for the MDP must apply the perspectives and procedures reviewed above. To explain again, the tasks are to predict expected demand for payments in the MDP area, select the appropriate technology to meet demand, and let financial institutions to invest in payment infrastructure in the area make the final decision.

6. Action Plans and Implications for the ICT Master Plan of the Marine Drive Project

In the final stage, this paper will summarize the action plans as follows based on the strategies for development of a digital payment system in the MDP area. Taking on the tasks together and considering the time schedule, they can be roughly classified as follows. The first two are immediate tasks, with the second two items to be completed in one or two years, and the last two items are long-term issues.

Action 1. Organizing decision-making body: payment council

This consultative body consists of the central bank and financial institutions. If necessary, an official from the MDP authority can join attend this body.

This body will be responsible for all matters necessary for the establishment of a payment and settlement system in the MDP area.

Action 2. Specifying and promoting the MDP's functions

Another urgent task is to determine which facilities will be installed for what purpose in the MDP area. For example, the early stage will see what entities will dominate commercial functions such as special tourist zones, financial hubs, entertainment including broadcasting or advertising, and high-end residential units.

Incentives can also help companies or facilities in the MDP to settle in the area as soon as possible. Stimulated business activities of the companies in the MDP area ensure the MDP's success as well as the efficiency of the payment and settlement system. Achieving economies of scale through demand expansion can secure infrastructure efficiency, an incentive for investment in infrastructure for payment and settlements.

Action 3. Designing a roadmap for a digital payment system for the MDP

The purpose of a multi-channel banking system is to provide a range of payment instruments and channels to support the variety of services offered in the MDP area.

Among the tasks included in the roadmap, several are considered urgent and need implementation as soon as possible. An example is a shared network for ATM, a rudimentary device for digital payment. Electronic funds transfer (ETF) is the next step as a catch-all term applicable to a wide variety of digital and e-payments such as e-cards, automated clearing houses and internet and mobile banking. To be decided by the payment council, specific tasks will become clearer once the MDP's functions are finalized.

At this stage, development of an ICT master plan is recommended in parallel with a roadmap for the MDP's digital payment systems. Also suggested is an investment plan for the ICT infrastructure of the region.

Action 4. Differentiation from other regions

ATM penetration in the MDP area must be raised to a significantly higher level than in other regions. Policy efforts must at least scrap the payment and settlement system that heavily relies on MM.

Action 5. Approach for periodical rolling planning in periods like every five years

Initial investments in the MDP area's payment systems and ICT infrastructure might not be optimally aligned with the MDP's functions. Such shortcomings, if found, should be corrected as soon as possible. In addition, digital payments and ICT infrastructure face rapid technological changes and need upgrades by accommodating rapidly evolving technologies. For these purposes, review and improvement of the payment system and ICT infrastructure are recommended on a periodical basis like every five years.

Action 6. Spreading successful case studies of the MDP nationwide

To maximize the contribution of the MDP to national economic development, successful case studies should be spread and applied nationwide.

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Appendix

<Appendix 2-1> Smart City & Digital Payments

Case Studies of Hong Kong & Singapore

Both Hong Kong and Singapore have promoted digital transformation for a long time and made considerable efforts to expand digital payment systems. In both places, digital transformation and innovation of payment systems were promoted separately in the early days but after the mid-2010s, smart city discussions began to include such systems.

1. Hong Kong

Hong Kong Special Administrative Region (SAR) promoted the smart city model relatively early. Starting with an announcement in 1998, plans to promote and utilize digital technology were announced in 2001 and 2004. In late 2007, the Government of Hong Kong (2007) again announced a plan to promote urban development using digital technology but made no mention of payment systems. Like other early discussions on smart city, such a system was omitted from the plan, which focused on raising the use of ICT devices such as the internet and mobile phones. The plan also contained Hong Kong's aspiration to emerge as a center of ICT activities by creating new industries using such technology.

Meanwhile, policy actions and activities related to digital payment were promoted separately from smart city. A typical example was the Octopus Smart Card, which was introduced in 1997 for use at transportation facilities. This card has the characteristics of a contactless smart card-based e-payment system run by Octopus Cards Limited, a separate company established in 1994 by Mass Transit Railway Corporation jointly with other related companies.

In 2000, Octopus Cards Limited was even licensed to accept deposits, allowing its card to be used not only for public transportation, but also at general stores and fast-food restaurants. In 2003, Hong Kong allowed the use of the cards to pay for public parking. After completing the necessary facilities around late 2004, the card was used for that purpose.

The Octopus Card is now a universal card for Hong Kong residents usable for most types of transportation or at a large number of stores, thus almost every resident has one. Adding

money to the card is usually possible in multiples of HKD 50. Card chargers (add value machines) are at major stations and take cash only. Change can also be added to this card after paying cash at retail stores and restaurants. The automatic add value service allows a user to add value to an Octopus card periodically with a certain amount from a credit card

Other examples of major digital payment systems in Hong Kong include the electronic payment system (EPS) and positive pay system (PPS). EPS uses a smart, credit, or debit card as a method of paying for goods or services, but the payment procedure follows the EFT method through the internet or online. EPS was jointly developed by 22 banks in 1985 but a separate company oversees operations.

PPS has a structure like that of EPS and is an e-payment method for paying public utility bills. PPS is a method of paying fees like utilities, government charges, telecom services, education services, and donations through channels like landline phones, internet-linked computers, and smartphones. Payment is conducted from pre-registered bank accounts 24 hours a day. PPS is jointly run by EPS Company and Hong Kong Telecommunications Limited.

In addition, Hong Kong's Monetary Authority in 2013 introduced systems like electronic bill presentment and payment and e-Cheque to facilitate payment and settlement by small and medium merchants. It also encouraged financial institutions including banks to use near field communication technology. These tasks were jointly developed and operated by the authority and commercial banks.

By the mid-2010s, the introduction of e-payment systems in Hong Kong was promoted by a host of economic entities but digitization of such systems was not reflected in the smart city plan.

Under the 2015 Smart City Promotion Plan (CPU 2015), modernization of the payment and settlement system was designated an important task. Emphasizing digital payment as part of the smart economy, the plan urged the government to expand financial infrastructure including promoting fintech, improving the efficiency of payment systems, distributing and managing financial data, and strengthening risk management in the financial sector. The report said financial infrastructure is necessary not just to enhance smart city functions but also for financial development.

The report also listed specific measures to improve payment system functions in Hong Kong, including the wider use of Octopus cards (CPU p.83). It also suggested stimulating

digital banking based on the internet or mobile devices. The report proposed to enact or amend payment laws so that more payment instruments available at retail outlets could be developed (CPU 2015, p. 84), recommending replacement of bond transactions with an e-check system.

Hong Kong seems to have a diversified governance structure for the operation of payment and settlement systems but no organization that makes systematic decisions on such systems overall.

2. Singapore

In 2000, Singapore announced a massive digital transformation. Its government expressed its ambition to become a vibrant city-state and global ICT hub by creating an e-economy and ICT-savvy e-society (IDA, 2000). Of the six strategies proposed to achieve the goals, that of online business, a plan to expand e-business infrastructure, was proposed. The report named electronic identification and authentication and digital payments as important tasks for such infrastructure, but the smart city concept was not applied at this stage.

In the early period, Singapore recognized the importance of digital payments as an important task in its digital transformation plan to achieve its aim of becoming a global financial center. The city-state's small area faces limits in development of manufacturing. Instead, better efficiency of the payment and settlement system was a must to develop service industries and finance, and the importance of this was recognized accordingly. In addition, Singapore is on the border between the Indian and Pacific oceans as a center of commerce and trade with a large volume of goods transported. Thus an efficient payment system is essential to effectively support such activities. The influx of numerous tourists also offers the country an incentive to set up a convenient payment and settlement system.

Thus in 2006, Singapore announced its adoption of a single card for use in public services throughout the city-state. Under this plan, the Specification for Contactless e-Purse Application (CEPAS) was applied in 2009. Like Hong Kong's Octopus card, this card was developed into a payment instrument usable for public transportation and the stores of small and medium merchants. Prior to this, the companies NETS and EZ-Link split the micropayments market, with the former dominating in retail and the latter in transportation. CEPAS unsuccessfully sought to unify these two cards, and different cards are used for different purposes.

Singapore promoted digital transformation early but the smart city concept was not introduced until the mid-2010s. More precisely, the city-state adopted the slogan "smart nation" instead of smart city. In 2014, Singaporean Prime Minister Lee Hsien Loong presented a vision of digitizing the country beyond the concept of a smart city (Lee 2014).

As the prime minister declared the promotion of smart nation, the Monetary Authority of Singapore (MAS) established the Smart Financial Center in line with the declaration. Through this organization, the models of several fintech companies were applied, leading to the setup of digital payment systems emerging as MAS' main task. Consequently, improvement of the payment and settlement system is now a key policy task in line with the smart nation campaign.

Singapore launched an organization to oversee payment-related policy measures handled by ministries and agencies. KPMG (2016) initially raised this issue and proposed to set up a decision-making body as a solution. Following this proposal, a payments council was opened in 2017 as a consultative body chaired by the MAS managing director and comprising about 20 stakeholders. The council implements policy tasks to create an e-payment society, playing a key role in activities like reducing interoperability problems between payment instruments, developing a single POS device, and revising or newly enacting related laws and regulations.

Thanks to these efforts, Singapore is rated the world's best smart city by think tanks worldwide. Yet many deficiencies linger in the country's payment system. The preference for cash is still dominant (Nyberg, 2021) and payment instruments are mixed, which increases inconvenience and the difficulty in selecting an appropriate card according to situation.

<Appendix 2-2> Ghana's Macroeconomic Situation & Financial System

1. Macroeconomic Development

As of 2021, Ghana had a population of about 30 million with annual growth of more than 2%. About 60% of the people live in cities. Urbanization is progressing fairly fast as the share of the urban population surged from 44% in 2000 to 51% in 2010 and 58% in 2021.

Ghana has seen relatively rapid economic growth since the mid-2000s. As of 2021, per capita GDP was USD 2,363 (World Bank data), an incredible jump of nearly five-fold from under USD 500 in 2005 thanks to several factors. In the late 2000s, exports of gold and cocoa jumped due to rising international prices of these items and in 2007, Ghana found oil and

began commercial production in 2011. The World Bank since 2011 has classified Ghana a lower middle-income country, up from low-income country (Aryeetey and Baah-Boatemgu, 2016).

Mining and raw material extraction account for a large proportion of Ghana's industrial structure. Gold, cocoa, and oil are major products that comprise most exports. The share of agriculture in the economy is falling and that of the service industry is rising. Overall productivity improvement is delayed by absorbing labor in the service industry with low productivity such as wholesale and retail (Geiger *et al*., 2019). In contrast, manufacturing is relatively underdeveloped as its output accounts for only 10% of GDP.

[Appendix Figure 2-1] Economic Growth & Industrial Structure

(Unit: %, USD)

Source: World Bank Open Data.

Looking at the demand side, the proportion of consumption is quite high. In the past, final consumption accounted for 100% of GDP and while falling recently, it remains at the relatively high level of 80%. Meanwhile, fixed capital formation, namely investment, accounts for about 20% of GDP, with most of it going into construction of buildings.

Trade dependence, or the ratio of exports and imports to GDP, remained at a high 60% in 2021, but this was lower than in the past. Foreign trade was quite active in the early 2000s, but dependence on it has since gradually declined. Imports are chronically exceeding exports because the domestic production base is underdeveloped to meet demand.

[Appendix Figure 2-2] Demand Structure and Trade

(Unit: %)

Source: World Bank Open Data.

2. Financial Systems

The financial sector has seen intermittent crises in recent years. In 2013, Ghana suffered a fiscal crisis. With the discovery of oil in 2007 raising economic prospects, inflows of foreign capital surged. The government issued large-scale foreign debt to expand investment in the oil and other sectors under favorable borrowing conditions. The Ghanaian government, however, spent a significant portion of the borrowings to raise the wages of civil servants. In reforming the public sector's pay system, authorities gave in to civil servants' demands ahead of the 2012 presidential election.

On the other hand, export tariffs in 2013 were reduced due to the collapse of gold prices, leading to a sharp drop in fiscal revenue, higher current account deficit, and soaring exchange rate amid the possibility of an interest rate hike in the US. Domestic consumption surged thanks to the hike in public sector salaries and expansion of imports. Another sharp rise in the exchange rate raised the burden of foreign debt and led to a vicious cycle culminating in a foreign exchange crisis. In 2014, Ghana requested a three-year arrangement under the extended credit facility of the International Monetary Fund (IMF), which approved a loan of USD 918 million in April 2015.

A banking crisis occurred in 2018. Due to nepotism and loopholes in governance, many banks suffered large-scale insolvency. The licenses of five banks were revoked and they were merged to form Consolidated Bank Ghana, with two were merged by the new entity. About 400 non-banking financial institutions were closed.

The development of Ghana's financial sector since the 2000s has remained stagnant due to repeated financial instability. In the 1990s, the M2/current GDP ratio continued to rise but has since stayed flat. In addition to chronic financial uncertainty, the nominal interest rate was cut and the real interest rate was around 0%, two leading causes of stifling incentives to save.

[Appendix Figure 2-3] Financial Development & Interest Rates

(Unit: %)

Source: World Bank Open Data.

In recent years, the inflation rate has largely stabilized but remains high at over 10% per year. In addition, the domestic production base is narrow and weak and a large part of consumer goods is imported, meaning price instability reappears intermittently when the overseas economic situation deteriorates. When international raw material prices surged in 2022, the consumer price index soared to over 50%.

[Appendix Figure 2-4] Inflation & Exchange Rate

(Unit: %, GHS/USD)

Note: annual change in consumer price index.

Source: World Bank Open Data.

Due to Ghana's chronic current account deficit, its currency GHS continues to depreciate and has proven extremely unstable in recent months. The exchange rate went from 8.32 GHS to the greenback in late August 2022 to 13.11 in mid-November that year. As negotiations for a stand-by agreement with the IMF began, the rate fell to 8.00 GHS on December 15. The IMF approved a credit line of USD 3 billion but the GHS weakened again, rising to 11.00 because of the widening current account deficit and other factors.

A key feature of Ghana's financial system is its diverse range of non-banking financial institutions, with many financial institutions specializing in serving rural areas. The number of micro-financial and special-purpose financial institutions such as rural banks are significant. In addition, the special-purpose bodies that handle payment and settlement

functions are a standout feature of Ghana's financial system. Telcos in charge of the financial intermediary function are also highly unusual.

<Appendix Table 2-1> Financial Institutions in Ghana

Type	No.	
Bank	23	
Savings & loans	26	
Finance house	11	
Leasing company	2	
Mortgage finance	1	
Finance & leasing	3	
Development bank	1	Development Bank Ghana Limited
Credit bureau	3	
RCB central (other bank)	1	ARB Apex Bank
Representative office	4	Korea Eximbank, Ghana Int'l Bank
Remittance company	1	
FX bureau	400	
Microfinance	136	
Financial NGOs	12	
Microcredit	29	
Rural & community banks	147	
Payment service provider	45	
Credit unions	500+	

Note: susu collectors & money lenders excluded.
Source: BoG's website (supervision & regulation section, access on October 23, 2022).

Among them, payment service providers (PSP) play an important role as a financial auxiliary institution whose main task is to assist merchants to collect sales proceeds. A PSP performs functions such as distributing a card reader and transmitting transaction data when an e-payment instrument such as a credit card is used. It is also called a payment gateway, third-party payment processing company, or embedded finance company.

A PSP can be seen as a financial assistance institution that appears to compensate the weaknesses of banks. Although banks need a license to run and their business has a public nature, the legal form is a private enterprise pursuing private interests. From a bank's perspective, profitability cannot be ignored because of the huge fixed costs incurred. Reflecting this, banks tend to try to maximize short-term profits.

In conclusion, banks find it difficult to operate branches in rural areas with small-scale financial transactions or regions with many lower-income earners. Against this backdrop, banks in developing economies have limited access to rural areas. A PSP is a financial institution that make up for the disadvantages of banks, which are inherently limited in expanding finance to rural or low-income areas.

A PSP is categorized into service distribution, technology supply, and account management institutions (Dresner *et al*., 2022). Refer to the following <Appendix Table 2-1> for their functions and types.

Ghana has four classes of licenses issued for PSPs. The scope of business is limited according to each license level. A PSP with an elementary license can perform only basic tasks such as mobile payment applications. The highest level of license is the dedicated electronic money issuer (DEMI), which hires merchants that supply mobile money (MM) and distribute e-wallets and offer payment services based on MM. DEMI also brokers remittances from overseas as well as domestically. As of 2021, Ghana had five PSPs licensed by DEMI.

<Appendix Table 2-2> PSP Types

	Distributor	Tech provider	B/S provider
Role	‣ Works with tech & B/S providers to embed financial products in customer, employee, & partner journeys	‣ Maintains & configures tech for delivering financial products to distributors via APIs	‣ Provides distributors with access to regulated license, risk framework, funds, & venue to hold deposits
Types	‣ Traditional retailers ‣ Software companies ‣ Marketplaces/platforms ‣ Telcos ‣ OEMs	‣ Fintech companies ‣ Banks	‣ Banks

Source: Dresner *et al*. (2022).

<Appendix 2-3> Ghana's Payment System Policy

The Bank of Ghana enumerates the goals of its payment systems policy as follows (BoG website; accessed on March 8, 2023):

- Prevent and/or contain risks in payment, clearing and settlement systems
- Form a robust oversight and regulatory regime for payment and settlement systems
- Ensure efficiency in the fiscal operations of the Ghanaian government
- Deepen financial intermediation
- Reduce the use of cash transactions while stimulating that of non-paper-based instruments
- Promote financial inclusion without risking the safety and soundness of the banking system
- Develop an integrated e-payment infrastructure to enhance interoperability of payment and securities infrastructure

Ghana has strengthened policy measures to develop its payments system for a long time. The focus was on creating a digital-based payment system starting with the launch of the Ghana Interbank Payment and Settlement Systems Limited (GhIPSS) in 2007. The following is a brief summary of the history of Ghana's payment system policy since 2007, when GhIPSS was established.

1. Events Since 2007

In 2007, GhIPSS was established with the main goal of achieving digital finance and the vision of making Ghana an e-payments-based society.

In 2008, GhIPSS launched e-Zwich, a smart card in which all financial institutions participate usable in all kinds of transactions such as deposits, withdrawals, and transfers with or between such institutions.

In 2008, Vodafone bought a 70% stake in the government-run Ghana Telecom.

In 2008, the Bank of Ghana announced the Branchless Banking Guidelines: Notice to Banks and Savings and Loans Companies. While adhering to the principle that banks should be the subject of financial services, the central bank sought to expand financial inclusion with major contributions from commercial banks through the guidelines. Based on this principle, its idea was to use telcos as agents or third-party service providers of banks.

The “many-to-many model” was adopted in which an agent cannot have an exclusive partnership with one bank and must maintain ties with multiple banks. Because the agent must deal with multiple banks, banks had no incentive to willingly step forward and make the necessary investment for e-payment settlement because its investment could help its competitors. This caused the 2008 guidelines to have little effect and served as the basis for guidelines that came later.

In 2009, MTN formed a partnership with nine banks and launched MM services in accordance with the 2008 Branchless Banking Guidelines. Opening an MM account with MTN was designed to be linked to a bank account at one of the nine banks having ties with MTN. Another condition was that thorough identification under a strict know-your-customer process was required to open an account. In other words, only those with a valid national ID could open an MM account. These constraints prevented the widespread use of MM. In addition to few people having national ID cards, the free rider problem causing banks to shun investment in digital payments was a serious problem.

In 2010, Tigo Cash was launched.

In 2010, the Ghanaian government announced a SIM card registration plan for all mobile phone operators to collect information to identify subscribers to each network. This plan sought to identify cellphone SIM card and chip owners and prevent crimes like phone theft, illegal texting, fraud, and threats.

In 2011, Airtel Money was launched.

In 2013, a financial crisis hit Ghana hard. After the discovery of oil that raised economic prospects, the government issued large-scale foreign debt but spent a significant portion of the loans to raise wages in the public sector. As the economic situation proved volatile in 2013, the government was unable to repay its external debts. In 2015, the IMF intervened to end the country’s insolvency fiasco.

In 2015, the BoG issued Guidelines for E-Money Issuers and Agents that significantly revised the 2008 edition. The new rules led to the adoption of DEMI and granted these institutions the same authority and ability to issue MMs as financial institutions. Telcos obtained DEMI status and used this position to independently issue MMs in a way not linked to bank accounts. Telcos scrapped their status as bank agents and assumed the role of special financial institutions that independently issue MM. A three-tier, risk-based approach to know your customer was applied by easing the identification process in the account opening

stage. Nevertheless, telcos inevitably had business partnerships with banks to complete payment as they could not disconnect from banks because of transactions between MM accounts and with bank accounts, plus other purposes.

In 2015, Vodafone Cash was launched.

In 2017, Airtel and Tigo merged to create AirtelTigo. In 2020, the government took over AirtelTigo.

In 2008, Vodafone bought 70% stake in Ghana Telecom, the first government-owned telco, and privatized the company into Vodafone Ghana.

In January 2017, MTN Ghana launched the merchant payment service MoMo Pay.

From 2017 to 2018, a banking crisis saw seven banks collapse because of moral hazard and corruption in the banking sector.

In 2018, the government presented the Digital Ghana Agenda to digitize government services, build a biometric national identity register, deploy a digital property addressing system, achieve MM interoperability, and adopt paperless port operations. (p. 5, forward)

In 2018, Ghana launched its first MM interoperability system to remove the complexities and inconvenience associated with transfers across MM networks like difficulties in opening bank accounts, high costs to maintain bank accounts relative to customer income levels, and financial literacy.

In 2019, the Payment Systems Act (Act 987) was enacted to enforce the 2015 BoG guidelines; it stipulates MM types, transaction limits, permissible transaction types, customer identification procedures, telco obligations to secure capital and liquidity, and obligations to protect consumers.

In 2019, the launch of Ghana Beyond Aid featured a plan for Ghana to become a leading digital economy in Africa by 2028.

In 2020, the Cybersecurity Act was enacted.

In 2020, the government announced a three-pronged digitization plan: the National Financial Inclusion and Development Strategy (2018–2023), Digital Financial Services Policy, and Cash-Lite Roadmap (2020).

In 2021, SIM card re-registration for the Ghana Card was launched as the only ID document required for all financial transactions with institutions under the authority of the Bank of Ghana. All SIM cards in Ghana are required by law to be re-registered with a Ghana Card by September 30, 2022. The requirement to register SIM cards was contained in a law passed by the Ghanaian government. The re-registration was initially scheduled from October 1, 2021, to March 31, 2022, and the major requirement for this was the Ghana Card.

In 2022, the Electronic Transfer Act took effect. The Ghana Revenue Authority (GRA) slapped a 1.5% e-tax on MM electronic transfers on May 1, 2022. An e-tax of 1.75% was imposed on e-transactions above GHS 100 separate from fees telcos charged customers for transactions.

<Appendix Table 2-3> Chronology of Payment Policy

Year	Events
2007	‣ GhIPSS established
2008	‣ Vodafone acquires 70% of Ghana Telecom
2008	‣ BoG releases Branchless Banking Guidelines
2009	‣ MTN launches MM services
2010	‣ Tigo launches Tigo Cash (MM)
2011	‣ Airtel Money launched
2015	‣ BoG issues Guidelines for E-Money Issuers & Agent Guidelines
2017	‣ President Nana Akufo-Addo inaugurated
2017	‣ Airtel & Tigo merged into AirtelTigo
2017	‣ MTN begins MoMo Pay for merchant payment service
2018	‣ Digital Ghana Agenda (2018)
2018	‣ GhIPSS begins MM interoperability system
2019	‣ Payment Systems Act enacted
2019	‣ Gov't announces Ghana Beyond Aid
2020	‣ Cybersecurity Act enacted, computer emergency response teams (CERTs) organized
2020	‣ Gov't announces Digital Payment Roadmaps - National Financial Inclusion & Development Strategy (2018-2023) - Digital Financial Services Policy - Cash-Lite Roadmap
2022	‣ Electronic Transfer Act enacted, e-levy (1.75%) for MM transactions above GHS 100
2022	‣ GhIPSS launches GhanaPay

Source: Author's own.

2. Policy Characteristics

Ghana is pushing digital transformation focused on finance, achieving major progress in payments and settlements. As a result, mobile money (MM) has achieved significant growth as government guidelines in 2015 spread the use of MM (Ifeanyi-Ajufo, 2022).

Yet the country still lacks proper and efficient payment and settlement systems to support economic development. The problem has apparently reached a crucial breaking point given excessive reliance on MM. A tax on MM transactions is considered a setback in the payment and settlement system, creating problems like rising use of cash payments.

Ghana is focused on supplying digital financial instruments or products, and its payment instrument digitization might have been done excessively. In contrast, measures to expand the demand base are insufficient, with nothing done to promote the development of commerce or manufacturing. In other words, much attention has gone to the spread and supply of digital financial instruments little to efforts to form a demand base utilized by such instruments.

The country seems to heavily rely on unilateral promotion by a public authority amid lack of innovation efforts by private financial institutions. Finding a cooperative relationship between the public and private sectors to apply new technologies is difficult. Payment system policy has suffered from lack of coordination with other sectors like macro-financial and financial stability policy. The volatility of macroeconomic conditions such as fiscal and financial crises, price instability, and soaring exchange rates are impeding the development of Ghana's financial sector and payment systems.

<Appendix 2-4> Korean Experience in Payment Council

This section covers Korea's experience in payment councils.

1. National Electronic Communication Networks in the 1980s

Korea boasts world-class information and communications technology (ICT) infrastructure, the basis for which was laid in the early 1980s by a national effort to build ICT networks in all sectors. Priority went to the financial sector, an implication of high relevance to this report.

In 1983, the Korean government released the Master Plan for Five Major Communication Networking Projects in public administration, finance, education, national defense, and law enforcement. In 1986, the Act on Electronic Communication Networks was enacted to legally support formation of communication networks. With this law, an implementation system for the project was established. An informatization project independently promoted by each ministry from the 1970s was converted into an integrated system and promoted at the national level.

To promote these projects, a decision-making body was designated for each project under the National Electronic Networks Coordination Committee, which was established within the Office of the President and chaired by the presidential chief of staff and received support from the Ministry of Information & Communication and Korea Electronic & Information Promotion Institute. The decision-making body in each sector was chaired by a deputy minister from the responsible ministry.

Refer to the following figure for the composition of the decision-making body for this project.

The project has run for almost 10 years, twice as a five-year plan.

2. Financial Information Networks

The Financial Information Network Promotion Committee (FINPC) promotes the computerization of the financial sector. Financial institutions organized FINPC under the Act on Electronic Communication Networks, which was enacted in 1986.

[Appendix Figure 2-5] Steering Organization for National Electronic Networks

Note: NENCC: National Electronic Networks Coordination Council
MIC: Ministry of Information & Communications
KEIPI: Korea Electronic & Information Promotion Institute
KCIA: Korea Central Intelligence Agency
NDA: National Defense Army
NIPA: National IT Promotion Agency
KFTC: Korea Financial Telecommunications & Clearings Institute
SERI: System Engineering Research Institute
Source: Ministry of Public Administration & Security (2017).

[Appendix Figure 2-6] Structure of Promotion of Financial Information Network

Note: FIPC = Financial Information Network Promotion Committee.
Source: Ministry of Public Administration and Security (2017).

FINPC was chaired by the Bank of Korea governor and its members comprised CEOs of financial institutions, with support from the central bank's payment department. FINPC had three subcommittees for banks, securities, and insurance. The steering committee discussed

and reviewed agenda items in which the heads of financial informatization departments, or ICT department directors, from each institution participated. The results were reported to FINPC and entered the final decision-making process. The final resolutions made by FINPC were requested to the Korea Financial Telecommunications & Clearings Institute (KFTC) for enforcement. Study groups in standardization, security, and other sectors used to advise the steering committee.

This report highlights two important and interesting issues in the process of financial information network (FIN) promotion by Korea in the 1980s. The first is that computerization of finance received the highest priority among the five sectors because of the huge spill-over effect of financial computerization (Ministry of Administration and Security, 2019, p.58). Despite giving top priority to this effort, the government decided to let financial institutions take charge instead of directly handling it.

3. First Roadmap for Financial Information Networks

FINPC announced the first FIN roadmap in April 1988 with the main theme of the modern concept of multi-channel banking, which has great implications for this study.

First, the roadmap suggested launching computer systems for each financial service. At the time, such services provided in developed economies were considered necessary in Korea from a future-oriented perspective. To install ATMs, for example, FINPC set up ICT infrastructure for this task called shared networks for CDs (cash dispensers) and ATMs. Several services were listed and the suggestion was to set up ICT infrastructure for each service as depicted in the table below to have each service have a suitable ICT infrastructure. In other words, priority in the initial stage went to equipping information devices and systems based on the characteristics of each financial transaction.

Over the long term, the roadmap suggested a strategy to promote a single financial computer network by integrating each system. Advanced economies operated individual systems independently, leading to the disadvantage of low connectivity between systems. To resolve this, the roadmap considered an integrated system and adopted standardization to unify the computer work of each financial institution as an important task.

<Appendix Table 2-4> Korea's FIN Roadmap of 1988

Financial services	ICT infrastructure
‣ CD/ATM	‣ Shared networks for CD/ATM
‣ EFT/POS	‣ Automatic sales settlement system
‣ Home banking	‣ Household-bank networks
‣ Corporate banking	‣ Company-bank networks
‣ ARS	
‣ Funds settlement	‣ Inter-banks fund settlement system
‣ Money transfer & remittance	‣ Inter-bank networks
‣ Credit information	‣ Credit information DB
‣ Cards	
	‣ Int'l & cross-border networks

Source: Bank of Korea (1988).

In conclusion, the payment system that Korea pursued under the 1988 roadmap was the same as the multi-channel banking system presented in this report. Building the latter system is a complex task intertwined with the interests of financial institutions. Korea boldly tackled this challenge by forming a decision-making body in which all financial institutions participated to form the cornerstone of an efficient payment and settlement system like that of today. In this respect, the decision-making structure and work promotion method Korea utilized at the time could be applied to the design of a digital payment system for the MDP in Ghana.

03

CHAPTER

The Smart Public Transportation Plan in the Marine Drive Project Area and Accra

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1. Transportation Conditions in Accra
2. Vehicle Growth and Traffic Conditions
3. Public Transportation Conditions
4. The Marine Drive Project in Accra
5. Korean Experience
6. Conclusion

Keywords
Smart Transportation, Public Transit, Electric Vehicle, Bus Information System, Bus Rapid Transit, Sustainable Transportation

The Smart Public Transportation Plan in the Marine Drive Project Area and Accra

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Summary

This report analyzes public transportation in Accra, identifies its limitations and challenges, and proposes comprehensive plans for improvement. The goal is to enhance the efficiency, accessibility, and sustainability of smart public transit in the Marine Drive Project (MDP) area while tackling the broader transportation needs of Accra. The Ghanaian capital faces numerous transportation challenges such as unreliable service and inadequate infrastructure that cause heavy traffic congestion, longer travel times, and environmental concerns.

The Greater Accra Metropolitan Area (GAMA) is grappling with the problems posed by a rapidly growing population and rising car ownership. With an estimated 4.5 million residents and daily influx of 2.5 million commuters, the region has seen a surge in the number of registered passenger cars, reaching 1.25 million in 2017. This figure accounted for 60% of registration nationwide and caused vehicles to dominate traffic volume in Accra, which accounts for 61% of the country's total. Trotros, or privately owned minibus share taxis with an extensive network of 315 routes and 11,195 registered vehicles, are the city's primary mode of public transportation accessible to most residents and commuters. The reliability of public transit is highly problematic, however, due to issues such as overcrowding, erratic schedules, and operational issues. In addition, the scrapping of bus rapid transit (BRT) plans and uncertainty in infrastructure development have compounded transportation challenges in GAMA. To face these issues, a comprehensive approach is needed to enhance public transportation reliability, implement sustainable solutions, and improve infrastructure development.

Accra's public transit system requires significant improvements to provide reliable and quality service to its residents. The proposed Smart Public Transport Plan for the MDP area

and GAMA aims to tackle challenges to create a reliable, eco-friendly, smart, affordable, and convenient system. The plan outlines short- to long-term initiatives to improve the public transportation network.

Over the short term, the plan suggests implementing five e-shuttles in a circular route within the MDP area and connecting it to Accra's central business district of Tudu. These electric buses are powered by sustainable energy to offer a cleaner and quieter alternative to combustion-engine vehicles, offering a reliable and convenient transportation options for residents, workers, and visitors in the MDP area, mitigating the lack of adequate services. In conjunction with these buses, the development of comprehensive systems for bus information (BIS), bus management (BMS), and automatic fare collection (AFC) is highly recommended. A BIS provides real-time data on bus schedules, routes, and arrivals, enabling passengers to plan their journeys effectively. A BMS aids fleet management, optimizes bus allocation, and ensures efficient operations. Furthermore, an integrated AFC system streamlines the ticketing process for better passenger convenience. The estimated cost of these initiatives is USD 1,415,000, covering buses, onboard equipment, BIS terminals, and charging systems.

The long-term plan seeks to set up a new circular BRT corridor with electric buses to connect key destinations, including the MDP area, with efficient and high-capacity bus service. This, however, requires expansion of road width due to right-of-way limitations, improvement of pedestrian-friendly venues such as streamlining sidewalks along main roads, and creating environments in small alleys more conducive to pedestrian activity. Development of well-designed walkways and improvement of pedestrian crossings will also boost access between the city center and MDP area.

The proposed Smart Public Transport Plan highlights the potential for a positive impact of sustainable transportation on GAMA's development and achievement of NDC targets. By tackling challenges and implementing short- to long-term initiatives, Accra and vicinity can secure a reliable, green, smart, affordable, and convenient public transportation system. This report stresses the urgent need for significant improvements in this sector, especially in the MDP area. By implementing the proposals, Accra can create a smart public transportation network of efficiency, accessibility, and sustainability to improve quality of life for residents, alleviate traffic congestion, and create a greener and more resilient urban environment.

1. Transportation Conditions in Accra

The rapid growth and urban sprawl of many cities in the developing world, coupled with higher access to motor vehicles, have produced negative consequences such as traffic congestion, high rates of accidents, and environmental damage, creating the leading causes of death in the developing realm. Despite efforts to improve transportation, the Ghanaian capital of Accra has not been spared from these problems, stricken with heavy traffic congestion and insufficient infrastructure to meet its transportation needs. Additionally, the nation's informal economy poses challenges to better public transportation due to low-cost alternatives.

2. Vehicle Growth and Traffic Conditions

The accelerated use of motor vehicles and urbanization in the developing world, along with unstructured and unregulated urban growth, have produced widespread traffic congestion and poor urban air quality from vehicular emissions. Accra is among the fastest growing urban centers in Africa, with annual population growth of approximately 2% since the mid-2000s (World Population Review, 2023). Over 4.5 million people inhabit Greater Accra, which receives a daily influx of 2.5 million commuters (Owusu, 2008). Over time, car ownership in the city has risen in line with personal incomes. In 2017, the number of registered passenger cars in the region was an estimated 1,250,000, or 60% of the country's total, with an average yearly increase of 8.4% over the last decade (Driver and Vehicle Licensing Authority, 2018).

In 2016, passenger cars accounted for the largest share of vehicles on roads with around 61%, followed by public transportation like trotros (private minibuses with seat capacity of 15 to 23 used as shared taxis) 18% and buses 1%. In Accra, informal transportation operators who use a variety of vehicles including trotros provide the majority of public transportation. Trotro has the largest share of any mode of transit in Accra with 62.2%, making it the most commonly used. Despite its widespread use, trotro has a relatively low road space utility of 18.3% of the available area.

[Figure 3-1] Share of Vehicles on Accra's Arterial Roads by Type

(Unit: %)

Note: This assessment was conducted before a BRT (Aayalolo) system was launched.
Source: KOICA and Ministry of Transport Greater Accra Regional Coordinating Council (2016).

The cumulative number of registered cars in Ghana since 1995 has reached 1,376,053. Greater Accra alone accounts for 890,511, or 64.7% of the total. Car ownership experienced rapid growth after 1995, with annual average growth by region ranging from 2% to 9.8% between 2000 and 2014. While the number of cars in Seoul is significantly higher than in Greater Accra, the former has maintained lower growth in vehicle population over the past 20 years. Accra's growth rate fluctuated between 8.5% and 9.5% over the last five years, as the area is still developing with ongoing improvement of its road infrastructure. In contrast, Seoul, a developed city with excellent public transit infrastructure and focus on sustainable growth, has maintained stable growth since 2005.

[Figure 3-2] Comparison of Greater Accra & Seoul: Cumulative No. of Registered Cars

(Unit: %)

	2000-2005	2005-2010	2010-2014	2014-2020
Greater Accra	8.77	9.55	6.89	
Seoul	4.38	5.61	0.61	1.85

Source of Seoul data: Seoul Statistics (2022).
Source of Accra data: KOICA and Ministry of Transport Greater Accra Regional Coordinating Council (2016).

Growth of car ownership has had a significant impact on traffic flow. Research by the Korea International Cooperation Agency (2016) in Accra found significant traffic volume during the morning and evening peak hours. From 07:00 and 08:00, average traffic volume was 3,105 vehicles per hour, something that worsened road congestion throughout the city. Nsawam Road was one of the most congested at this time as it had the highest traffic volume of any street in Accra. Similarly, the evening peak period from 17:00 to 18:00 saw average traffic volume increase to 3,190 vehicles per hour. Nsawam also had the highest traffic volume during this time. The number of vehicles on this route highlights the need for targeted intervention to alleviate traffic congestion and improve vehicular flow in the area.

In addition, the MDP area also experiences high traffic volume during peak evening hours. From 17:00 to 18:00, the average traffic volume there is 1,682 vehicles per hour, signaling the urgency of intervention to alleviate congestion. Effective and reliable public transportation options such as bus service or mass transit systems can reduce reliance on private vehicles and alleviate traffic in the MDP area, improving overall traffic flow in Accra.

[Figure 3-3] Traffic Volume on Accra's Arterial Roads

Source: KOICA and Ministry of Transport Greater Accra Regional Coordinating Council (2016).

3. Public Transportation Conditions

Public transportation in Accra plays a crucial role in reducing traffic congestion in the capital. The city has three primary modes of public transit: trotro, Aayalolo, and Metro Mass Transit (MMT). Trotro is the most prevalent form with a staggering 315 routes and 11,195 registered vehicles, with an extensive network covering almost every corner of the city that makes trotro easily accessible to residents and commuters. Despite this, trotro suffers from overcrowding and erratic schedules that cause operational problems and delays.

In 2016, the government introduced Aayalolo as a modernized bus rapid transit (BRT) system. With initial procurement of 245 buses, this system aimed to provide reliable and efficient transportation for Accra's residents. Yet service now is limited to just 50 buses serving four specific routes: Accra-Amasaman, Adenta-Accra, Kasoa-Accra, and Ofankor-Accra.

MMT, operated by Ghana's central government, plays a crucial role in intra- and inter-city transportation in Accra. Its fleet comprises 1,049 buses, 32% of which serves routes within Accra. This big fleet enables MMT to serve a wide range of passengers and contributes to the city's public transportation system.

[Figure 3-4] Public Transportation Network in Greater Accra

Notes: Uncertainty corridor tracing on map.

Source: (Photo top-middle) Transitec Consulting Engineers (2017); (Photo bottom) State Interest and Government Authority Ghana (2017). (Map) Created by author.

Like in many emerging cities, transportation is an essential issue in Accra. With a steadily growing economy and population, efficient mobility has turned problematic. Accra remains behind in the quality of mass transit for residents, something that this smart public transportation project is trying to solve. The following list summarizes the main problems in public transportation as indicated by newspapers in the capital:

- Longer passenger wait times at terminals to access public transportation
- Longer travel times due to congestion
- Poor maintenance of buses that causes high fuel consumption
- Lack of adequate bus stops, with buses stopping randomly whenever a passenger stands on a route
- Failure of buses to fully operate on schedule or according to timetable

If not resolved soon, more problems can arise from those poor public transportation conditions in Accra like:

- Worsening of socioeconomic and environmental issues from transportation
- Lower mobility and longer commuting times
- Decline in living standards and rising economic costs
- High levels of greenhouse gas emissions and noise pollution

3.1. Trotro

Trotro provides public transportation using minibuses that can typically carry 15 to 23 passengers; the service is primarily run by informal service providers. Trotro generally runs fixed routes without properly enforced stops, so passengers can get on and off as desired, especially at a driver's discretion. This mode of transportation grew popular due to the demise of the omnibus service after the Omnibus Service Authority and the government opted to privatize public transportation in 1996.

Trotro has extensive network coverage but its headway and travel time reliability are problematic in Accra. A driver can make multiple stops to pick up or drop off passengers. On average, passengers wait 22.6 minutes before a trotro departs from the terminal. A survey showed that 22% of passengers had a waiting time of 5–10 minutes and 15.4% 20-30 minutes. In travel time, the average time for a passenger to reach a destination was 55.5 minutes. The highest travel duration to reach a destination was 10–30 minutes for 27.2% of passengers and 30–40 minutes for 25.7% (KOICA and Ministry of Transport Greater Accra Regional Coordinating Council, 2016).

[Figure 3-5] Avg. Waiting Time for Trotro

Minutes	%
Under 5 min	11.2
5 – 10 min	22.0
10 – 20 min	40.4
20 – 30 min	15.4
30 – 50 min	8.0
50 – 60 min	1.8
Over 60 min	1.2
Total	100

[Figure 3-6] Avg. Travel Time for Trotro Passengers

Minutes	%
Under 10 min	2.1
10 – 30 min	27.2
30 – 45 min	25.7
45 – 60 min	21.5
60 – 90 min	12.4
Over 90 min	11.1
Total	100

Source: KOICA and Ministry of Transport Greater Accra Regional Coordinating Council (2016).

A correlation was found between trotro fares and the distances traveled, something usually adjusted by the Ghana Road Transport Coordinating Council (GRTCC) when fuel prices increase. The fares are fixed and can range from as low as GHS 0.60 to GHS 2.50 or more depending on distance traveled. On average, trotro fares are nearly twice those of MMT. The former mode of transit is considered affordable but also crowded and uncomfortable, especially during peak hours.

Trotros are also linked to dilapidation, poverty, and filth. Passengers frequently complain about a vehicle's condition, discourtesy of other passengers, and road hazards. Government officials criticize trotro drivers for charging high fares, and media report accidents involving this mode of transportation. Reckless driving is considered part of a trotro driver's social and cultural identity (Hart, 2016). While trotros are a convenient and accessible mode of transportation for many in Accra, they are also considered a symbol of the city's congested and often chaotic traffic conditions.

3.2. Aayalolo

The Aayololo Bus Rapid Transit (BRT) System was launched on November 25, 2016, in Accra. A unique feature of this system is designated bus lanes for faster travel on routes through traffic. The Aayololo system linked Accra to the cities of Amasaman and Ofankor. Initially set up as a BRT system with dedicated lanes, it was later renamed the Quality Bus System due to the unavailability of those lanes along the entire routes. Aayalolo is also under the Urban Transport Project of the Ministry of Roads and Highways and Greater Accra Passenger Transport Executive.

Aayololo operates 50 buses that travel on four routes: Accra-Amasaman, Adenta-Accra, Kasoa-Accra, and Ofankor-Accra. Among these, 15 buses serve the Kasoa-Accra route, 25 Amasaman-Accra, and 10 Adenta-Accra (Safo, 2019; Agyeman, 2019). The combined length of the corridor, which lacks dedicated or exclusive lanes, is 92 kilometers yet the service has a daily demand of approximately 6,000 passengers (The Ghana Report, 2018).

Despite the lack of bus lanes, the government has no plan to remove or relocate the trotro fleet from the corridor. Select bus stops are designated BRT lanes exclusively for Aayalolo, but with no security personnel to monitor things, all trotro vehicles use these stops. Trotro drivers reject the priority of Aayalolo buses at stops due to lack of enforcement and their use of the corridor before the BRT system. Trotros thus often obstruct Aayalolo buses and wait for incoming commuters to board, resulting in fierce competition between both services at stops. This shows how bus lanes have failed to fully carry out their purpose: transporting passengers at high speed.

The Ghanaian government procured Aayalolo buses and subsequently leased them to bus operating companies at lower fares per trip than trotro operators covering the same distance. Initially, the Aayalolo system was designed to use e-cards as payment, but its management could not provide these to customers after card supply ran out. Due to financial and technical challenges, Aayalolo operations were halted in October 2018 but resumed service on all routes in April 2019.

[Figure 3-7] Conditions of Aayalolo Bus Service

Note: √ means that the item meets the standard and X that it does not.

Source: BRT Standard by ITDP (2016), with checklist evaluation created by author.

The 2016 edition of the BRT Standard said Aayalolo failed to meet most standard criteria, especially those of BRT basic and infrastructure. As a result, the system is unable to provide optimal service to users. Nevertheless, Aayalolo has shown a promising start by meeting safety requirements and ensuring universal access.

[Figure 3-8] History of BRT Systems in Accra

Source: Asimeng (2021).

Three main reasons explain the collapse of the Aayolo BRT System and its downgrade (Lartey, 2019; Korankye, 2021):

- Competition between trotros and BRT: Trotos had no restrictions and almost all of the vehicles were old and outdated but still allowed anywhere near the city center or even on the same routes as the BRT system.
- Financial and technical hitches: The lack of funding and commitment of politicians who usually make the decisions also impacted the smart card's operation and maintenance. The bus service in use does not use smart cards.
- Reliability issues: Operators failed to keep their pledge to get passengers to their destinations on time because the buses had to merge with regular traffic at certain points along the route since the dedicated lane was only 2 km.

A study by the Institute of Green Growth Solutions (IGGS, 2019) on factors behind public avoidance of the Aayalolo service in Accra identified the following factors:

- Limited routes and accessibility: The Aayalolo service has a limited number of routes, making access difficult in certain areas.
- Inadequate feeder services: The feeder services connecting passengers to the main Aayalolo service are often unreliable or unavailable, rendering use of the service difficult.
- High fares: Aayalolo costs more than other modes of transportation such as trotros, making it less affordable and attractive. For example, trotro fares range from GHS 0.60 to GHS 2.50 but Aayalolo charges GHS 3.50 from Accra to Amasaman.
- Poor customer service: Passengers have complained of bad experiences with customer service from Aayalolo staff, discouraging them from using the service.
- Inefficient operations: Other passengers slammed Aayalolo for inefficient operations such as long wait times and delays in bus arrivals.

<Table 3-1> User Reasons for Avoiding Aayalolo Bus Service

(Unit: %)

	Total
Need for smart bus card	44.23
Limited places to buy & top up card	7.21
Slower	5.77
Seen for rich or high-income earners	7.69
Infrequent	13.46
Only stops at designated spots	12.02
Other	9.62

Source: IGGS (2019).

3.3. Metro Mass Transit (MMT) Limited

In March 2003, Metro Mass Transit (MMT) Limited was founded as a limited liability company under the Companies Code 1963 Act 179 to provide safe, affordable, efficient, and reliable transportation for commuters in metropolitan and municipal areas (Abdul-Azeez, 2009; MMT, 2008). MMT is a public-private partnership between the government, which owns 45%, and private organizations (55%). As of late 2008, MMT had a fleet of 1,066 buses and transported 173 million passengers throughout Ghana but has struggled with low returns on investment. This prompted the government to form a committee in 2010 to investigate its activities over the years. Presented to the Ministry of Transport, the committee's report recommended that MMT management subsidize a percentage of spending on acquiring its buses (Baah-Mintah and Adams, 2012).

The 1,049 buses in Accra provide transportation within the city and intercity areas,

with intercity routes having the largest number of buses (KOICA and Ministry of Transport Greater Accra Regional Coordinating Council, 2016). A benefit of MMT services is the fare, with free rides for students on weekdays. Additionally, MMT fares are approximately 50% cheaper than those of other private intercity buses. But like many other government-owned public transportation systems, MMT fails to meet quality standards. Certain buses often lack functional air conditioning and others have poorly maintained interiors.

[Figure 3-9] MMT Bus Service

Picture and data source: KOICA and Ministry of Transport Greater Accra Regional Coordinating Council (2016).

3.4. Light-rail Transit Plan

In 2020, Ghana's Ministry of Railway Development, in collaboration with Systra, conducted a feasibility study for a metro rail and rail transit system in Accra. The proposed Accra light-rail transport (LRT) in this study has a distance of approximately 20 km, stretching from the Adenta Barrier in the north to the central market in Accra's bustling city center. The LRT primarily follows the path created by Legon Road, Liberation Road, and Independence Avenue, strategically aligning with roads. The proposed system will efficiently serve major mobility generators such as the central market, central business district (CBD), airport area, University of Ghana, and rapidly developing areas like East Legon, Madina, and Adenta.

Considering the corridor's dense traffic flow and urban landscape, most LRT alignments have been elevated, with only minimal grade-level sections. This approach mitigates impact on the urban fabric and ensures smooth traffic flow. The planned corridor incorporates 19 stations, three of which are optional, resulting in an average interstation distance of 1,050 meters to meet standards for mass transit systems.

The LRT stations will also serve as trotro stops, with a dedicated platform for trotro at

several stations under consideration. To facilitate seamless passenger movement, key stations will have related services as intermodal hubs like minibuses for the university (University LRT station) and seamless air passenger movement to the LRT station from the airport. These hubs will meet the diverse needs of commuters and enable efficient transfers between modes of transportation for a streamlined and convenient experience for passengers.

By 2030, peak hour ridership in LRT will reach an estimated 8,000 passengers, resulting in approximately 20,000 trips on the LRT line during morning rush hour on 21 trains. Moreover, daily ridership is expected to reach 280,000 passengers, with an annual total of 90 million using the line. To enhance the appeal of LRT service, adjustments are planned for the headway, or the time interval between trains. This interval will be reduced to five minutes and later to four and 2.5 minutes to attract more passengers by offering higher service frequency and reliability. In fare structure, LRT fares are set to align with the average trotro fare, which is GHS 2 plus an additional GHS 0.1 per kilometer. This approach ensures that LRT remains affordable and competitive in relation to other transportation options while promoting a seamless transition for commuters from the trotro system to LRT.

[Figure 3-10] LRT Plan and Passenger Demand Forecast in Accra

Year	PPHPD	MPH boardings	Daily boardings	Yearly boardings
2030	7,800	20,000	280,000	90,000,000
2050	12,000	30,000	440,000	140,000,000
2070	18,000	50,000	700,000	220,000,000

Note: PPHD = passengers per hour per direction; MPH = morning peak hour.
Source: Systra (2020).

4. The Marine Drive Project in Accra

The Marine Drive Project (MDP) is a major infrastructure venture under development in Accra. The plan is to transform a 241-acre stretch of land along the city's coastline into a modern recreational and tourism hub, promoting economic development and job creation. The MDP features facilities like a five-star hotel, marina, commercial center, theme park, restaurants, cafes, stores, and residential units. Green spaces and public parks for recreational activities like jogging and cycling are also planned, as well as venues to hold sporting and cultural events. The MDP will be on beachfront land in Accra, connecting the road from James Fort - Ussher Castle - Osu Castle spanning 4.13 km.

[Figure 3-11] MDP Area

Source: Author.

The project was initially designed to boost tourism in Ghana by providing world-class facilities for visitors and creating jobs in hospitality and tourism. The Ghana Tourism Authority initiated the MDP in collaboration with private developers, attracting support from a variety of stakeholders like the central government, international development partners, and the private sector. In general, the project's initial objectives were:

- Develop beachfront area in Accra into a viable tourism enclave
- Intensify land use to meet the high value of land and counteract its scarcity in Accra
- Foster an environment for attracting high tourism investment in the city center
- Create jobs and income opportunities, especially for local communities
- Set up revenue streams for the chiefs and people of the Osu and Ga traditional councils

These objectives, however, were changed depending on conditions. Regardless of the situation, the MDP is expected to play a crucial role in the government's broader efforts to energize the capital and promote economic growth and development.

The MDP in Accra is ongoing, and in 2020, the Ghanaian government announced investment of over USD 1 billion in the project to accelerate its completion. The government said the project is expected to create over 150,000 jobs and significant economic benefits for Accra. Smart and eco-friendly public transportation is essential to support the large-scale modern development of the MDP. The area is exclusively serviced by trotros but people can also use Aayalolo buses to reach the CBD and walk 800 meters to 1 km to the MDP area.

[Figure 3-12] Public Transportation Network in the MDP Area

Source: Created by author.

The traffic volume and travel speed around the MDP area are less than optimal, with roads experiencing traffic delays of up to 25 km per hour. To facilitate the region's development, a dependable bus rapid transit (BRT) system with dedicated lanes is required. The BRT system can benefit the MDP by reducing greenhouse gas emissions by enhancing the public transit system and providing better access to the MDP through a high-quality public transportation network. As seen in [Figure 2-3], traffic congestion on roads surrounding the MDP area is severe and expected to worsen after the project's completion. Thus sustainable public transportation systems that minimize the use of private vehicles are urgent. This study is crucial for preparing for the development of such systems.

[Figure 3-13] Traffic Road Conditions in the MDP Area

Source: Google Maps. (2023).

4.1. Smart Mass Transit Plan for the Marine Drive Project Area and Accra

Public transportation in Accra needs major change. Due to a growing population and lack of proper urban design, the capital's roads have seen a surge in vehicular activity that causes traffic congestion and pollution from vehicles. Over the past few years, owning and operating a car has grown more affordable for a significant portion of the population and Accra residents. This has increased the number of vehicles on roads, worsening traffic congestion. The city also has significant urban sprawl, and people keep moving further away from the CBD. The result is commutes of longer distances as the CBD accounts for the primary source of Accra's economic activity (Brookins, 2019). In addition to enormous time costs and safety hazards for travelers, these factors have harmed the environment.

Accra's rapid population growth and keeping up with urban planning to accommodate increased trips have fueled the predominance of the informal transportation sector in

the city, mainly minibus taxis called trotros. The service typically uses older vehicles in which passengers are frequently crammed beyond capacity. The informal transportation market is largely unregulated, leading to safety hazards, environmental damage, and traffic congestion. Roughly 60% of the population relies on trotros due to low cost and flexibility, as the service offers affordable fares and customizable routes based on demand. Due to the limited availability of Aayalolo and MMT vehicles, privately owned cars are the No. 2 form of transportation for Accra residents, exacerbating traffic congestion and carbon emissions. Investment has gone into improving Accra's public transportation, but additional solutions are required given issues stemming from increased trips.

Ghana in 2015 showed its intent to fight climate change by submitting intended Nationally Determined Contributions (NDC), which included specific targets for urban transportation such as increasing public transportation trips 10% in four major cities, implementing sustainable mass transportation modes like rail and bus rapid transit (BRT) systems, reducing travel time by at least eight minutes per trip using public transit, and lowering traffic congestion (UNFCC, 2022). The Ghana Urban Transport Project launched the Aayalolo bus service as part of the BRT initiative on the Amasaman, Adenta, and Kasoa routes to achieve these targets. Poor ridership and unsustainable financial challenges have hindered its success, however. The development of a BRT system has the potential to reduce CO2 emissions by 1.63 million tons by 2040 if combined with other climate change mitigation measures. The electrification of the Aayalolo system could help Ghana achieve its goal of 10% increase in public transportation trips and the NDC target of reducing emissions 15% (UNEP, 2022). Furthermore, development of Aayalolo into a BRT system could alleviate traffic congestion in Accra and align with the New Urban Agenda's goal of improving transportation and mobility infrastructure systems to enhance efficiency, connectivity, accessibility, health, and quality of life for urban residents.

With the right features, a BRT system can prevent delays. Seven essential features typically define such a system to ensure more reliable and convenient transit: dedicated right of way; bus-way alignment; off-board fare collection; intersection treatment; platform-level boarding; intelligent transportation systems; and institutional arrangements.

In summary, the state of Accra's public transportation is as follows:

- Less reliable
- Scrapping of BRT system
- Uncertainty over infrastructure development plans such as those for road construction and pedestrian-friendly streets
- CO2 reduction target in transportation by NDC (109,900-ton reduction by expanding inter- and intra-city transportation modes)

To meet NDC targets and confront public transportation challenges in Accra, several improvements are needed in public transportation based on five principles: reliability, green, smart, affordability, and convenience.

[Figure 3-14] Main Principles of Public Transportation Improvement in Accra

Source: Created by author.

4.2. Short-term Plan

To enhance transportation in the MDP area of Accra, a comprehensive short-term plan uses initiatives and projects. A critical component of this plan is an e-shuttle service that offers convenient and efficient transportation options for residents and visitors. The service will operate along a circular corridor within the MDP area, ensuring connectivity between neighborhoods, and provide a vital link to Tudu in the CBD. The service is expected to bring numerous benefits to the MDP area. Through a reliable and frequent shuttle service, residents and employees there can access more convenient transportation options and reduce their reliance on private vehicles and alleviate traffic congestion. The e-shuttle will cater to visitor needs, enhance their mobility within the MDP area, and facilitate their exploration of surrounding attractions and amenities. Along with e-shuttle service, the two mobility hub options are one in Tudu and the other in the MDP's parking garage. A mobility hub will accommodate electric vehicle charging infrastructure and house transfer facilities that promote the use of public transit and shared mobility means such as bicycles and quick boards. The plan calls for developing a bus information system (BIS) to help passengers quickly access data on bus routes and schedules. To support this system, automatic fare collection will streamline fare payment by passengers.

The short-term plan will include the following:

- E-shuttles:
  - Circular corridor in the MDP area
  - Development of two mobility hubs

- Development of systems for bus information (BIS), bus management (BMS), and automatic fare collection

[Figure 3-15] Tudu Station

*Disclaimer: the routes here might be different from the actual ones due to the limitation of route information. The maps could be improved in the future.

Proposed mobility hub + charging station

Source: (Map) Created by author.
(Photo) Taken by author (November 2022).

4.2.1. E-shuttle and Mobility Hub

The MDP area is busy with tourists all day and other activities in the evening. E-shuttle service can transport visitors along Marine Drive and passengers from the old and new BRT corridor in Tudu to the inner MDP area.

The e-shuttle service has a combined 16 bus stops (Figure 3-3). The average distance between each stop is approximately 550 meters, with a minimum distance of 450 meters and maximum of 700 meters. This distance was calibrated considering the physical capability of visitors and their willingness to walk comfortably. Considering these factors, the placement of stops aims to accommodate the needs of commuters while also considering proximity to points of interest and road intersections. This insightful approach ensures that passengers can conveniently access the stops, facilitating efficient and seamless travel experiences within the system.

The adoption of mobility hubs is part of the plan to improve public transportation in the MDP area. The hubs are crucial staging facilities for e-shuttle service, ensuring efficient operations and convenient passenger access. Specifically, they will be installed at BS 1, Tudu BRT Terminal, and BS 16, a future transportation hub in the MDP area and get integrated with modes of transportation to provide convenient and seamless connections for passengers and offer charging infrastructure to support electric vehicles. Incorporation of mobility hubs into the transportation network will enhance the accessibility and sustainability of public transportation options within the MDP area of Accra.

Specifications of the proposed e-shuttle are:

Avg. travel speed	: 20 km/h
Operating hours	: 06:00 – 21:00 (15 hours)

Route 1

Hourly frequency	: 6
Headway	: peak hours → 10 min
	: off-peak hours → 15 min
Combined distance	: 1.5 km
No. of buses	: 3
Total km per day per bus	: 858 km

Route 2

Hourly frequency	: 3
Headway	: 20 minutes
Combined distance	: 4.7 km
No. of buses	: 2
Total km per day per bus	: 733 km

Total no. of buses	**: 5 e-shuttles**

Source: (Image) Accessed on March 2023. (www.sustainable-bus.com/ electric-bus/hyundai-county-electric-minibus/).

[Figure 3-16] E-shuttle Bus Stop Plan

Notes: BS 1 is Aayalolo Bus Terminal and BS 16 is MDP Mobility Hub.

4.2.2. Bus Information and Management Systems

The short-term plan incorporates the bus information (BIS) and bus management (BMS) systems into e-shuttle operations. The BIS collects location information from buses, generates estimated arrival times for each station, and provides travel information to a bus information terminal (BIT) and mobile devices.

Each user or organization has access to the following essential information:

- Traffic information center: analyzes operating history and manages bus operations and routes

- Passengers/residents: search for routes, access operational data, check estimated arrival time, and views real-time bus position information
- Drivers: receive space interval information and stay informed on traffic conditions along bus routes
- Bus companies: manage vehicle allocation and analyze operating history
- The BIS system has the following advantages:
- Enhance quality of public transportation by ensuring punctuality in bus operations
- Promote and increase bus usage through high quality BIS
- Raise user convenience with fast and accurate bus operation information
- Enable efficient bus operation management and monitoring by public organizations and bus companies

[Figure 3-17] BIS Operations

Source: ITS Korea, accessed on March 2023. (intl.its.go.kr/en/02_05_02).

In addition to BIS, the complementary BMS comprises systems for data gathering, processing, and provision. The data gathering system collects information on buses and their routes through GPS devices and transmits bus-related data in 20-second intervals as buses arrive and depart from each bus stop to the data center through a wireless data

communications network. The data processing system sorts and compiles received data into databases via communications and location processing servers. Finally, the data provision system delivers the processed information to stakeholders such as the public, bus companies, drivers, and policymakers through servers.

The BMS leverages automatic vehicle monitoring and fare system data to optimize planning and service. The data collected can be utilized for planning, analysis, reporting, and administrative purposes such as planning, scheduling, resource optimization, performance, and contract management. By identifying system flaws, the BMS helps make quick decisions to fix them. An ICT provider can develop a graphical dashboard that displays real-time information on bus operations and financial transactions such as passenger boarding at stations, issued tickets, buses in operation, and bus positions and speeds. Output reports can be generated for varying levels of management, ranging from daily to weekly or monthly reports.

[Figure 3-18] Example of Dashboard Screen: GPS Integrated

Source: BRT Planning Guide, Institute for Transportation and Development Policy, accessed on March 2022. (brtguide.itdp.org).

4.2.3. Cost Estimation

The cost estimation for the short-term plan of the proposed Smart Public Transport Plan in the MDP Area and Accra is USD 1,415,000 including the components necessary for implementation. The BIS and BMS, which require five buses and 16 bus stops, have a projected cost of USD 415,000. The e-shuttle system of five electric buses costs around USD 800,000

and the charging system infrastructure another USD 200,000. These calculations provide a preliminary assessment of the financial investment required for the short-term plan, serving as a valuable reference for budgetary considerations and potential funding sources.

[Figure 3-19] Expected Cost of Short-term Plan

EV-shuttle system

5 buses

$800,000

+

$200,000

(Fast charger (>100kW), including installation cost)
(The number of charger is determined by number of e-buses and their frequency)

BIS/BMS system

Assuming 5 e-shuttle buses + 16 bus stops

ITEM	Unit price (USD)	Total (USD)
Onboard equipment	5,000	25,000
Bus information terminal	10,000	160,000
S/W (including digital map)	100,000	100,000
H/W, Communication	100,000	100,000
Cloud center S/W	-	30,000
Total	-	**415,000**

Seoul TOPIS → $1,415,000

Source: Author.

4.2.4. Other Issues

The success or failure of a public transportation system greatly depends on its fare collection system. The short-term plan seeks to streamline the system in e-shuttle systems. Paper tickets manually require considerable human effort, causing delays for customers and potential loss of revenue. To resolve these issues, technology has advanced electronic devices such as smart cards for more innovative and secure fare collection, enabling a faster and more efficient process. Since Aayalolo buses accept such cards, Accra can try the new payment system for e-shuttles in a pilot operation of a small scale.

Demand for BRT services is influenced by factors at the overall system and route-specific levels. The system level includes variables that impact overall BRT demand like the number of available vehicles, size of the population being served, fares charged for the service, implementation of an integrated transit fare system, and number of BRT routes operating in the network. Additional influential variables should be considered when considering BRT service demand on a per-route kilometer basis. They include the number of vehicles

operating on the bus route, fare charged for that route, number of stops along the corridor, use of an integrated transit fare system, number of BRT routes that intersect with the given route, and population density in areas served by the corridor.

Understanding these variables and their influence on BRT demand is crucial for effective planning of and optimizing BRT systems. By considering factors such as vehicle availability, fare structures, integrated fare systems, route connectivity, and population density, transportation authorities can make informed decisions to meet demand for BRT services and ensure efficient and sustainable public transportation options for the communities they serve.

4.3. Long-term Plan

The proposed long-term plan for transportation improvement in the MDP area features several key initiatives. The first is to develop a new circular BRT corridor using electric buses for sustainable and efficient transportation. This corridor, however, could require road widening due to limitations on right of way. The second initiative features a pedestrian-friendly improvement such as upgrading sidewalks along the main road and creating a more pedestrian-friendly environment in smaller alleys. These initiatives can make the MDP's transportation system more accessible and convenient, improving quality of life for residents and visitors alike.

[Figure 3-20] Proposed Long-term Plan

The long-term plan includes:

- New circular BRT corridor (circular route) with electric buses. The government must act toward road widening due to the right-of-way limit.
- Pedestrian-friendly improvements
  - Sidewalk upgrades along main road
  - Creating pro-pedestrian environment in small alleys

Source: Created by author.

The development of the service plan for the new circular BRT corridor reflects several key parameters. The service will have an hourly frequency of four trips, and peak hours will have a headway of 10 minutes between buses and 15 minutes in off-peak hours. The corridor's combined distance is 19.5 kilometers. Four buses are used for this service, each covering a daily average 390 kilometers. By carefully considering these parameters, the new circular BRT corridor will provide efficient and reliable transportation to residents and visitors in the area, alleviating traffic congestion and improving overall mobility.

The service plan for the new circular BRT corridor includes:

Hourly frequency	: 4
Headway	: peak hours à 10 min
	off-peak hours à 15 min
Combined distance	: 19.5 km
Total km per day per bus	**: 390 km**

4.3.1. BRT Route Selection

The selection of the circular corridor is based on a previous study that proposed Line C-1 as a circular corridor, as shown in [Figure 3-8]. In 2017, the Korea International Cooperation Agency (KOICA) collaborated with Ghana's Ministry of Transport and the Greater Accra Regional Coordinating Council to conduct a study on transportation in the capital. Twelve arterial bus routes were recommended for large buses known as "arterial buses," a reformed version of the trotro system, with remaining trotros to eventually connect to these routes from residential areas. KOICA suggested using six of the 12 routes as a complete BRT system. Four planned BRT routes were implemented (see Figure 3-9). Based on the BRT masterplan from the previous study, KOICA proposed prioritizing Line C-1 that connects the MDP area to other neighborhoods.

The new BRT corridor area considers the future LRT plan for Accra (see Figure 3-7). Spanning 20 km from Adenta Barrier in the north to the central market in the city center, the LRT project plays a vital role in the capital's transportation infrastructure. The central market near the MDP area is near the new BRT corridor. The intersection between the proposed new BRT route and LRT system is also found in the Ring Road area. This integration between the BRT and LRT networks aims to provide commuters seamless connectivity and efficient travel options, enhancing accessibility and mobility in Accra.

[Figure 3-21] Arterial Bus Network Plan

Line	Routes	Length
Line 1	Kasoa~CBD	27.4km
Line 2-1	Amasaman~CBD	21.2km
Line 2-2	Ofankor~CBD	14.6km
Line 2-3	Ofankor~Circle	23.1km
Line 3-1	Adenta~CBD	19.3km
Line 3-2	Madina~CBD	16.4km
Line 4-1	Tema~Sakaman	39.0km
Line 4-2	Tema~CBD	33.1km
Line 4-3	Ashaiman~Circle	31.5km
Line C-1	Ringroad-Circulation	19.8km
Line C-2	Achimota~Labadi	27.3km
Line C-3	Sakaman~Ringroad	19.7km

Source: KOICA and Ministry of Transport Greater Accra Regional Coordinating Council (2016).

[Figure 3-22] BRT Master Plan

Source: KOICA and Ministry of Transport Greater Accra Regional Coordinating Council (2016).

4.3.2. BRT Corridor Alignment

Due to limitations on the right of way in the area, expansion of road width is necessary to accommodate the BRT corridor to accommodate buses and provide sufficient space for passengers to safely board and disembark. Though road widening poses complexity and

challenges, effective implementation of the corridor is crucial to deliver the desired benefits to residents and visitors. Investment in road widening can improve transportation options in the area and fuel the growth and development of the community.

Road infrastructure in Accra poses challenges for the corridor. Most sections of roads have only two lanes in each direction, and in certain cases, only a single lane is available (see Figure 3-10). The broader roads with four lanes per direction are limited to the Ring Road area. Given that BRT requires dedicated lanes for efficient operation, road widening is a must for accommodating the system. By widening roads and designating dedicated lanes, the MDP area can see improved traffic flow and reduced congestion. Accra can also benefit from enhanced public transportation systems.

[Figure 3-11] illustrates an instance of road widening required for the corridor in Accra, providing a visual representation of the areas along the proposed BRT route where road widening is necessary to accommodate BRT-only lanes. This depiction conveys the extent and locations of road widening, providing a clear understanding of infrastructure adjustments needed to integrate the BRT system into Accra's road networks.

[Figure 3-23] No. of Traffic Lanes in Accra

Map source: Created by author.

[Figure 3-24] Limited ROW on Proposed New Circular BRT Corridor

Source: (Map) Created by author.
(Photo) Google Street View (2023).

[Figure 3-25] Sample of Cross-section of Ring Road E & Prof Atta Mills High Streets that needs widening to provide BRT corridor

Source: Created by author.

4.3.3. Pedestrian-friendly Improvement

Acknowledging the importance of pedestrian safety, Ghana has taken significant steps through its Pedestrian Road Safety Action Plan for the Accra Metropolitan Assembly (AMA)

from 2018 to 2022. This comprehensive plan was a collaboration between the Blomberg Initiative for Global Road Safety (BIGRS) and the AMA to enhance pedestrian safety throughout the region. This plan covers issues like the safety of children walking to school, inadequate street connectivity, and high reliance on walking and public transportation.

A WRI report (2017) found that walk-only trips accounted for 12% of all Greater Accra travel, while those using public transportation comprised 62%. This suggested that over 70% of AMA residents likely walk as part of their daily travel. Unfortunately, an analysis of traffic fatalities and severe injuries from 2011 to 2015 showed that pedestrians accounted for nearly three-quarters of deaths (69%) and half of serious injuries (50%) in the AMA (Bloomberg Initiative, 2017). This highlights the urgent need for implementing Ghana's National Road Safety Strategy III (NRSS III) and its Action Plan, which specifically focuses on enhancing pedestrian safety. By prioritizing the needs of pedestrians, Ghana aims to reduce the alarming rate of pedestrian casualties and create safer streets for people using roads. This objective is pursued through the incorporation of elements (Bloomberg Initiatives, 2017) like:

1. Promoting safety at pedestrian crossings at junctions and on main roads
2. Making streets more walkable by building pedestrian walkways every kilometer of streets per year and maintaining and managing two kilometers of walkways
3. Managing public street space for pedestrian safety
4. Ensuring safe journeys to school
5. Enforcing safe speeds for pedestrians
6. Rethinking urban planning to favor pedestrian safety
7. Engaging the public and road system designers to improve pedestrian safety and awareness

[Figure 3-26] Mode Share including Non-motorized Transportation

(Unit: %)

Source: WRI (2017).

[Figure 3-27] Traffic Fatalities & Severe Injuries from 2011 to 2015

(Unit: %)

Source: Bloomberg Initiative (2017).

Aligned with the vision and mission of the Pedestrian Road Safety Action Plan for AMA, this study proposes the creation of pedestrian-friendly areas in the CBD (Tudu) and MDP area while also connecting the proposed mobility hubs in both locations. These areas require improved connectivity because of high population density and foot traffic, resulting in safety risks for pedestrians. Enhancements such as wider sidewalks, pedestrian crossings, and traffic signals aim to make navigating these areas on foot more accessible and safer. Moreover, pedestrian improvements can boost foot traffic to nearby businesses and support the area economy since the section from the CBD to the MDP area is a hub of commercial activity. Promoting pedestrian-friendly environments can foster more sustainable modes of transportation like walking or biking, which can alleviate traffic congestion, reduce air pollution, and stimulate exercise. Promoting a pedestrian-friendly environment in these areas positively impacts safety, economic vitality, and environmental sustainability, which ultimately support the AMA vision of becoming a safe, smart, sustainable, and resilient modern city.

Safe and accessible pedestrian infrastructure provides the means for making this mode of transportation feasible. Pedestrian connections also mark a critical transition between modes of transportation. Related facilities provide people with space to travel within the public right of way separated from vehicles on roadways. They promise to improve mobility for pedestrians and provide access and alternative means of travel to and from home, work,

parks, schools, shopping areas, and transit stops; for children, they also provide places to walk, run, and play. Places with no walkways or those in poor condition or missing sections often have the following conditions:

- People might be forced to walk on roadways, causing more accidents between pedestrians and vehicles.
- Without a safe and well-maintained place to walk, people are discouraged and, in extreme cases, prevented from walking.
- Lack of sidewalks can remove access to all destinations for many disabled people.

In 2016, KOICA collaborated with the Ghanaian government to develop the Non-Motorized Transport network plan in Greater Accra as part of the Transport Master Plan Project in the Greater Accra Metropolitan Region project. The primary objective was to ensure safety and create pleasant conditions for pedestrians, especially in areas with high traffic. To achieve this, the focus was on implementing measures (KOICA and Ministry of Transport Greater Accra Regional Coordinating Council, 2016) including:

- Installing facilities to separate pedestrians from vehicles if road width is sufficient
- Designating roads as vehicle-pedestrian or pedestrian-only roads if road width is insufficient
- Securing enough space for pedestrians by introducing one-way streets
- Setting up facilities to prevent parking on sidewalks and designate and expand crosswalks
- Building small parks and rest places given their heavy pedestrian traffic

As part of this initiative, this study proposes pedestrian-friendly areas shown in the figure below. Suggestions include sidewalk improvements along the main road covering an approximate distance of 3.5 km on both sides, providing safer and more comfortable walking spaces that enable pedestrians to move freely and safely alongside vehicular traffic. As part of the transportation improvement plan in the MDP area, streamlining of pedestrian infrastructure and creating a more pedestrian-friendly environment are the focus.

[Figure 3-28] Proposed Pedestrian-friendly Improvement in City Center Aligning with Prior KOICA Studies

NMT network plan improvement by KOICA (2017)

Type	Exiting	Improvement	Total
NMT Network	105.9km	134.5km	240.4km
NMT Link	48.9km	152.0km	200.9km

Proposed pedestrian-friendly area in this study

Map source: (top) KOICA and Ministry of Transport Greater Accra Regional Coordinating Council (2016), (bottom) created by author.

Furthermore, designing a pedestrian facility is more than just creating a sidewalk. Proper placement and provision of the necessary elements are vital to ensuring accessibility for all. The following are the best practices recommended for designing pedestrian facilities.

[Figure 3-29] Ensuring Dedicated Pedestrian Zones on Sidewalks

A Multi-utility zone
With a minimum width of 0.6 m (should be adjusted based on the type of street furniture installed) or 1.5 m if it is a green lane.

B Pedestrian zone
With a minimum width of 1.5 m to accommodate two pedestrians passing each other, or a minimum width of 1.8 m to accommodate wheelchair movement.

C Building frontage zone
With a minimum width of 0.75 m (should be adjusted based on building functions and the presence/absence of sidewalk commercial space)

Source: (Photo) Accessed on March 2023. (Dreamstime.com).

The objective is to create a sidewalk accessible to users of all ages and abilities. The primary focus of the design concept is (ITDP, 2021):

- Continuous sidewalk
  - Providing an obstacle-free moving space with a minimum width of 1.5 meters (1.8 meters is recommended to accommodate passing wheelchair users)
  - Ensuring no interruption by a driveway lane, road furniture, or other objects
  - Installing ramps for any height difference on the pedestrian path

- Crossings that prioritize pedestrians
  - Marking with a minimum width of 2.5 meters
  - Making the crossing distance as short as possible
  - Providing ramps to accommodate access for disabled people
  - Placing crossings at every approach of the intersection or mid-blocks with a maximum 80 to 100 meters distance from other crossing points
  - Building a refuge island accommodating disabled people on roads with more than two lanes

- Pedestrian-friendly intersections, especially on smaller streets
  - Offering a waiting space for pedestrians before crossing
  - Shortening the crossing distance as much as possible
  - Minimizing corner radii to add pedestrian space and reduce vehicle speed when turning
  - Providing pedestrian refuge islands for wide crossing (more than two lanes)

[Figure 3-30] Benchmarks of Pedestrian-friendly Measures in Seoul

Continuous sidewalk and crossing that prioritize pedestrian in Seoul, South Korea	Pedestrian friendly intersection in smaller streets in Seoul, South Korea

Photo source: Taken by author.

5. Korean Experience

5.1. Transportation Conditions in Seoul

As the capital of Korea with a population of around 10 million, Seoul has nine subway lines spanning a combined distance of 327.1 km as well as 7,279 buses and 2,969,000 vehicles registered. Of the 31,885,000 daily trips made by all modes of transportation, buses account for 28%, subways 37%, passenger cars 23%, and taxis 7%, with the share of subways slightly increasing and that of buses declining.

[Figure 3-31] Use of Transportation Modes in Seoul

Source: (Top) Seoul Metropolitan Government: Seoul Public Transportation Report, accessed on March 2023.
(Bottom) Collected by author based on Seoul Statistic data 2008 to 2019.

5.2. Bus Rapid Transit System in Seoul

Bus service in Seoul has faced multiple challenges due to the increasing number of vehicles. Worsening traffic congestion around the city made it difficult for buses to provide punctual service and caused more people to drive or use other transportation options. As ridership declined, operators competed for more profitable routes and passengers, compromising service quality. In response, the Seoul Metropolitan Government (SMG) upgraded its bus service to a BRT system as part of its historic 2004 reform of public transit. Retrofitting a BRT system into the city's network was challenging but the city went further by integrating the system seamlessly with other modes of transportation.

The capital has four types of buses:

- Red buses quickly connect the Seoul metropolitan area, downtown, and sub-centers.
- Blue buses run significant transportation nodes.
- Green buses service residential areas and traffic nodes, covering shorter distance routes and running at slower speeds as they stop at most major subway and bus stations outside the city center.
- Yellow buses run routes that circle areas within downtown areas.

[Figure 3-32] Classification of Seoul Buses

Red Bus	Blue Bus	Green Bus	Yellow Bus
Fast connection between metropolitan area and city sub- centers, absorbing vehicle traffic into and out of the city	Fast and on time connection between suburban areas, city center and sub-centers	Transfer connection between trunk lines and the subway, handling local demand and increasing accessibility	Handles demand in city center, sub-centers and shopping areas, flexible according to demand

Source: Seoul Metropolitan Government: Seoul Public Transportation Reform / A Brand New Seoul Report, accessed on March 2023.

According to 2022 data, 354 bus routes were operated by 65 bus companies. A combined 7,249 vehicles were used to service these routes, attesting to the large scale of the bus transportation industry and complex network of companies and routes used to provide this essential service. Managing such a large and diverse system requires careful planning, coordination, and effective management of resources such as vehicles, drivers, and infrastructure.

<Table 3-2> Supply of Seoul Buses

Classification		No. of companies	No. of routes	No. of buses
Blue	Truck lines	55	128	3,565
Green	Feeder lines	60	224	3,443
Red	Inter-regional lines	5	11	227
Yellow	Circular lines	1	1	14
	Total	65*	364	7,249

Note: The total number of bus companies is 65 since one company can operate multiple types of bus routes. In addition, night buses also run on 14 routes in Seoul.

Source: (left) Seoul Metropolitan Government: Seoul Public Transportation Report, accessed on March 2023.

To provide more convenient service, the SMG and bus companies jointly created a user-friendly bus service through a system offering bus-related details and transfer amenities that include:

- Transit card: This card is used to ride buses and subways and offers a discount when transferring.
- Transit transfer center: These centers at major transportation hubs facilitate bus transfers. The centers are primarily located within the BRT area and provide additional amenities such as bus information terminals (BITs) and air conditioning systems to enhance the waiting experience for passengers transferring buses.
- Reform of bus routes The SMG altered the intricate bus route structure through a new color-coded system, which includes red buses that service Seoul's metropolitan and downtown areas and sub-centers. Blue buses connect significant transportation hubs in the capital with residential areas and traffic nodes that intersect with subway lines. Green buses, which previously traveled within a specific region like CBD areas, were replaced by yellow buses that run on circular routes.
- Bus operation management system This system monitors bus operations, tracks incidents, and settles fares.
- Provision of information on real-time operations A bus operation management center facilitates convenience by offering passengers access to route and operating information and real-time bus arrival times through BITs at bus stops, mobile devices, and the website.

[Figure 3-33] Bus Service in Seoul

Source: Created by author.

5.2.1. BRT Infrastructure

5.2.1.1. Exclusive Median Bus Lanes

Exclusive median bus lanes play a crucial role in ensuring the reliability of service in Seoul by prioritizing buses on the city's roads. These lanes are separated from the rest of traffic, allowing buses to run at higher speeds and maintain punctuality. The SMG implemented bus-only lanes as early as 1990 to improve the efficiency and accessibility of bus travel. The effectiveness of outside bus lanes, however, was often marred by problems such as illegal roadside parking, right-turning traffic, and vehicles entering or exiting side streets, all of which disrupted the flow of bus traffic.

Moving bus lanes to the middle of the road sought to more effectively separate bus traffic. The first median bus lane debuted in 1996 along Cheonho-daero Road and was soon expanded with the 2004 public transportation reform to Dobong-Mia-ro, Susaek- Seongsan-ro, and Gangnam-daero. Over the years, bus lanes have consistently expanded with average annual growth of 15 km. As of 2017, Seoul had 120.5 km of such lanes, with plans to double the length to over 223 km. The city has a combined 329 median bus stops and the combined distance of such lanes jumped from 12.7 km in 2003 to 124.2 km with 13 axes in 2021.

Site selection for the lanes is based on factors like number, overlapping with subway lines, traffic concentration and volume, and bus traffic volume per 20 hours. Roads with heavy and frequent traffic congestion are given priority.

[Figure 3-34] Median Bus Lanes in Seoul

Source: (Top) SUSA (2019).
(Bottom) Seoul Statistic (2022).

[Figure 3-35] Design of Median Bus Lanes

Source: Created by author.

5.2.1.2. ICT System in Seoul: Seoul TOPIS

ICT systems also play a crucial role in ensuring the delivery of high-quality BRT services by handling large passenger volume and providing fast and reliable financial transactions, customer information, and operating systems. By reducing the need for personnel, such systems can lower costs and streamline daily operations. The integration of ICT systems has grown more sophisticated over time, using a system-oriented approach that promotes cooperation among transportation modes and expediting mobility system management. The ICT system has three main areas: BIS, BMS, and fare collection.

Seoul TOPIS (Transport Operation & Information Service) is a transportation data system developed by the SMG to provide accurate and up-to-date data on transportation to the public. The system collects data from sources like buses, subways, and taxis and processes it to offer comprehensive information including real-time arrival times, bus locations, and traffic conditions. This data is available to passengers through channels such as BITs, mobile devices, and the website. The system's purpose is to improve transportation efficiency and convenience in Seoul.

Seoul TOPIS' comprehensive traffic management system gathers data from a variety of sources including vehicle detecting systems, CCTV, and automatic vehicle identification installed on roads, as well as on-board equipment and taxi GPS for bus and taxi information. TOPIS' traffic management system also incorporates information on accidents, disasters, construction, and others by connecting with the National Police Agency or collecting it from individuals. Additionally, transportation card data used on buses and subways is also collected. By integrating and analyzing this data, Seoul TOPIS performs continuous 24-hour monitoring and surveillance to manage road traffic, public transit, disasters, and emergencies.

[Figure 3-36] Main Systems of Seoul TOPIS

Source: Seoul TOPIS (2023).

5.2.1.3. Bus Information System in Seoul

The BIS in Seoul's BRT system provides passengers with real-time information on bus routes, schedules, and locations. The concept of data collection and processing is illustrated in [Figure 3-37]. The SMG operates the BIS and covers all buses running in the city. The system comprises several components including GPS tracking devices installed on buses, digital signage at bus stops, and a mobile app that passengers can download. The tracking devices on the buses provide real-time location data transmitted to the central control center, allowing the system to calculate estimated arrival times and update digital signage at bus stops accordingly. Passengers can also use the app to track the location of buses in real time, view estimated arrival times, and plan their routes plus get information about bus schedules, fares, and changes or delays in service.

The data collected for the BIS includes:

- Real-time bus location (GPS data) and bus speed
- Arrival and departure times at a bus stop
- Operating information (no stop at a bus stop or reckless driving)
- Number of boarding and disembarking passengers at a bus stop
- Data on incidents

[Figure 3-37] BIS Operation of Seoul TOPIS

Source: Seoul TOPIS (2023).

[Figure 3-38] Bus Information Terminals in Seoul

Photo sources: (left) Kojects (2023), (right) taken by author.

The BIS in Seoul has several notable features. Its data collection rate has improved from 93% to 97%, ensuring more accurate tracking of buses in real time. The accuracy of data on bus arrival times jumped from 76% to 94%, ensuring that passengers have timely and reliable transportation. The BIS has installed bus information terminals (BITs) at approximately 60% of the city's 6,221 bus stops, with higher installation rates at stops that service five or more bus lines compared to those that service four or fewer (78.2% vs. 36.5%). BITs allow passengers to access real-time data on bus routes, schedules, and estimated arrival times, boosting the overall public transportation experience. Illustrations of BITs are shown in [Figure 3-38].

Based on smart card data, a BIS function provides information on the level of in-vehicle crowdedness. This information is presented in three groups, allowing passengers to decide which buses to board or avoid especially during peak hours. Overall, the BIS in Seoul incorporates advanced technology to provide passengers with real-time information and improve the efficiency and quality of public transportation services. In providing convenient service, the BIS has the following effects:

- Over 700,000 people use BIS services daily on computers, smartphones, or other mobile devices.
- More than 600,000 access public transit apps on their smartphones each day and around three million app downloads occur daily.
- A combined 1,267 BITs are installed at major bus stops by the SMG, with an estimated 31% of bus passengers using BITs at bus stops or railway/subway stations.

5.2.1.4. Bus Management System in Seoul

The BMS of Seoul TOPIS integrates and manages information on public transportation including buses and subways. It also handles violations by bus companies such as buses failing to stop at designated stops, reckless driving, and operating costs. The BMS provides important information to bus drivers like headway and accident reports and shares this data with media platforms including BITs, mobile apps, web portals, and Open-API. Its provision of vehicle management information to bus companies enables optimization of operations and improve service quality. Overall, the BMS in Seoul TOPIS is a critical component of the city's public transportation infrastructure, ensuring that bus and subway services are managed efficiently and providing important information to drivers and passengers through a range of channels.

Real-time bus data is gathered in Seoul through information collection terminals equipped with BMS and traffic card functions installed on all buses. These terminals collect comprehensive data on all aspects of buses such as operational status from the time of departure to the time of arrival, real-time location, speed, sudden stops and acceleration, bypassing designated stops, divergence from assigned routes, and driving with the door open. Additionally, the terminals can check information on transportation cards for real-time collection of passenger-related data.

[Figure 3-39] BMS in Seoul TOPIS

Source: Seoul TOPIS (2023).

5.2.1.5. Fare Collection System in Seoul

In Seoul, an e-payment system allows the use of a single smart card on buses, subways, and taxis, enabling travelers to transfer between modes of transportation to streamline the payment process to make travel more convenient. Charges paid by card are distributed to transportation companies after account settlements through data processing, ensuring that efficient and accurate payment processing. Over 95% of bus and 100% of subway passengers in Seoul use this card, making it the dominant payment method. The card of the capital's top transportation card company T-money is used for 96% of bus, 100% of subway, and 40% of taxi fares. In 2012, 95.39% of bus passengers paid with smart cards, demonstrating the near-universal e-payment use in city transportation.

The automatic fare collection (AFC) system uses a smart T-money card that passengers can buy and top off at designated locations. A passengers taps the card on a card reader at a bus or subway station to pay the fare. The amount is automatically deducted from the card's balance, eliminating the need to carry cash or purchase tickets or tokens. The card is also usable on taxis or private buses in Seoul and even at designated retailers and vending machines. The AFC system improves public transportation's convenience and efficiency

while reducing cash handling and ticket printing costs and waste. The system was applied from July 2004 to buses and subways in Seoul and subways in Incheon and expanded to buses in the surrounding Gyeonggi-do in July 2007, those in Incheon in 2009, and the airport railroad in 2010.

[Figure 3-40] History of AFC System in Seoul

Source: Created by author.

5.2.2. E-bus and Charging System

The SMG is trying to reduce greenhouse gas emissions and improve air quality through adopting electric buses (e-buses) as part of its public transportation system. The capital as of 2021 had about 670 e-buses operating, with plans to increase the number to 1,000 by 2022. Such green vehicles emit far fewer pollutants (namely zero emissions while operating) than traditional diesel buses and provide a quieter and more comfortable ride. The charging system uses several chargers to support e-bus operations, with two types commonly used for overnight charging: AC slow and DC fast. The former needs four to five hours to fully charge an e-bus while the latter takes just 30 to 60 minutes for a full charge, making them suitable for charging during the day. In addition, wireless chargers are installed at select bus stops, allowing e-buses to charge while waiting for passengers at a lower charging efficiency.

The city is also raising the use of electric vehicles (EVs) as depicted in [Figure 3-41]. For example, a demonstration project in 2008 delivered electric motorcycles in cooperation with a private pizza franchise. The following year, a master plan for development of charging infrastructure stipulated how EV chargers could be provided along with the level of their deployment. At the early stage of mobility electrification, the municipal government targeted buses, shared cars, and taxis. Considering buses' longer travel distances and higher consumption of fossil fuel, buses are often targets for electrification to cut carbon emissions and save energy.

[Figure 3-41] History of Electric Vehicle Deployment in Seoul

Source: Created by author.

Another case study of e-buses is from Suwon, Gyeonggi-do. This southern Seoul suburb's charging station system for its e-buses reduced carbon emissions and improved air quality. An e-bus charging station is designed to provide quick and efficient charging to ensure operations with minimal downtime. The charging system in Suwon uses a pantograph, an arm that extends from the station and connects to a charging port on the e-bus's roof for quick and easy charging without manual connection and disconnection. The station is part of Suwon's larger effort to promote sustainability and reduce the environmental impact of public transit.

[Figure 3-42] E-bus and Charging Stations in Korea

Source: (left) Sustainable bus, accessed on 2023. (sustainable-bus.com). (right) Hankyoreh (2019).

The SMG's range of policy actions has sought to promote EV deployment. One was the purchase requirement that mandates that all public vehicles of the city government and affiliates must be EVs from 2019. Thus the public sector is setting an example by transitioning to cleaner and more sustainable transportation options. Another measure is EV parking supply requirements. Public buildings with 100 or more parking spaces must allocate at least 3% of their spots for EV charging, ensuring adequate infrastructure to support EV adoption.

To further stimulate the use of EVs and reduce emissions, the city set up a low-emission zone in the downtown area. Vehicles with heavy emissions that enter this zone are subject to fines to encourage the use of clean fuels and discouraging the use of polluting ones. Additionally, conventional ride-sharing cars have been replaced with EVs, promoting eco-friendly transportation options for residents and visitors alike. These measures demonstrate the city's commitment to sustainable mobility and promotion of EVs as a viable alternative to fossil fuel-powered vehicles. Through incentives, improved infrastructure, and strict enforcement of emission regulations, the capital is actively working toward becoming a greener and more eco-friendly city.

[Figure 3-43] Green Transportation Zone in Seoul

Source: Author.

5.2.3. Satisfaction with Public Transportation in Seoul

Overall public satisfaction with mass transit in Seoul saw a gradual increase from 76.8% in 2012 to 82.6% in 2015, indicating that residents positively view improvements in infrastructure, technology, and fare integration. Specifically, bus service's positive rating increased from the upper 40% level before reform to the upper 60% level afterwards in 2015, suggesting that residents were pleased with the changes in the system.

[Figure 3-44] Public Satisfaction with Bus System after Reform (infrastructure, technology, and fare integration)

Source: Seoul Metropolitan Government (2016).

6. Conclusion

6.1. Implementation

The proposed Smart Public Transport Plan in Ghana's MDP area and Accra is divided into short and long term to improve the efficiency, accessibility, and sustainability of smart public transportation in the area while considering the broader transportation needs of Accra. This plan aims to create a sustainable city by achieving the Nationally Determined Contributions (NDC) target for reducing greenhouse gases through enhancing the quality of public transportation services, slashing carbon emissions, and promoting a greener urban environment for both residents and the larger community.

The short-term plan for improving Accra's smart public transportation system covers a range of initiatives designed to accelerate the use of e-shuttle and enhance transportation infrastructure. A key component is the installation of two mobility hubs with charging stations and procurement of five e-shuttle buses to include development of a BIS and BMS for improved passenger convenience to provide a seamless and user-friendly experience for commuters in the MDP area.

Accra's long-term plan includes deployment of e-shuttle buses on a circular BRT corridor to enhance the city's transportation system by providing eco-friendly and efficient public transportation for residents and visitors alike. E-buses are expected to reduce carbon emissions to promote a cleaner and healthier environment. Furthermore, the corridor is expected to improve the reliability and convenience of the transportation system, offering a trouble-free passenger experience. Road width, however, has fueled worry. As the corridor requires wider roads, expansion projects are necessary to ensure a smooth transportation system. Road widening is critical to ensure that the corridor operates efficiently and safely, providing a more sustainable and improved transportation experience for all. Additionally, upgrades of 3.5 km sidewalk section is planned. Improving accessibility from the city center to the MDP area will provide more public access to the MDP area.

6.2. Final Thoughts

This report on the Smart Public Transport Plan in the MDP Area and Accra includes major policy implications for transportation management and development as summarized in [Figure 3-45].

The short-term plan's policy implications including e-shuttle buses, BIS, and BMS will positively impact the MDP area by creating a green area with reduced pollution while improving public access. Through e-shuttle buses likely to comprise electric or low-emission vehicles, the plan reduces pollution and creates a more eco-friendly MDP area. The BIS enhances public access by providing real-time information on bus routes, schedules, and arrival times, making navigating and utilizing public transportation easier. And the BMS ensures efficient operations that enhance the overall user experience. These measures emphasize the importance of integrating technologies and systems for a sustainable, accessible, and user-friendly transportation network in the MDP area.

The long-term plan promotes sustainable transportation through a new corridor with a full BRT system and pro-pedestrian area. Its policy implications go beyond the MDP area to include the broader impact on Accra and achievement of NDC targets. By creating a dedicated corridor for a BRT system on the ring road, Accra can improve its public transportation network, reduce traffic congestion, and enhance overall sustainability. Known for its efficiency and reduced environmental impact, the BRT system aligns with NDC goals of expanding inter- and-intra-city transportation modes and reducing carbon emissions. Additionally, the emphasis on pedestrian-friendly areas promotes more active improvement of transportation and creates a safer and more livable urban environment.

[Figure 3-45] Policy Implications

Note: Created by author.

The policy implications derived from this study and the short- and long-term plans emphasize the importance of integrating sustainable transportation solutions, collaborating with stakeholders, allocating adequate budget, aligning policy with national development goals, and using monitoring and evaluation mechanisms. By considering these implications in carrying out comprehensive plans, policymakers can ensure the success of the Smart Public Transport Plan in the MDP Area and Accra, ultimately creating an efficient, accessible, and eco-friendly urban transportation systems.

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