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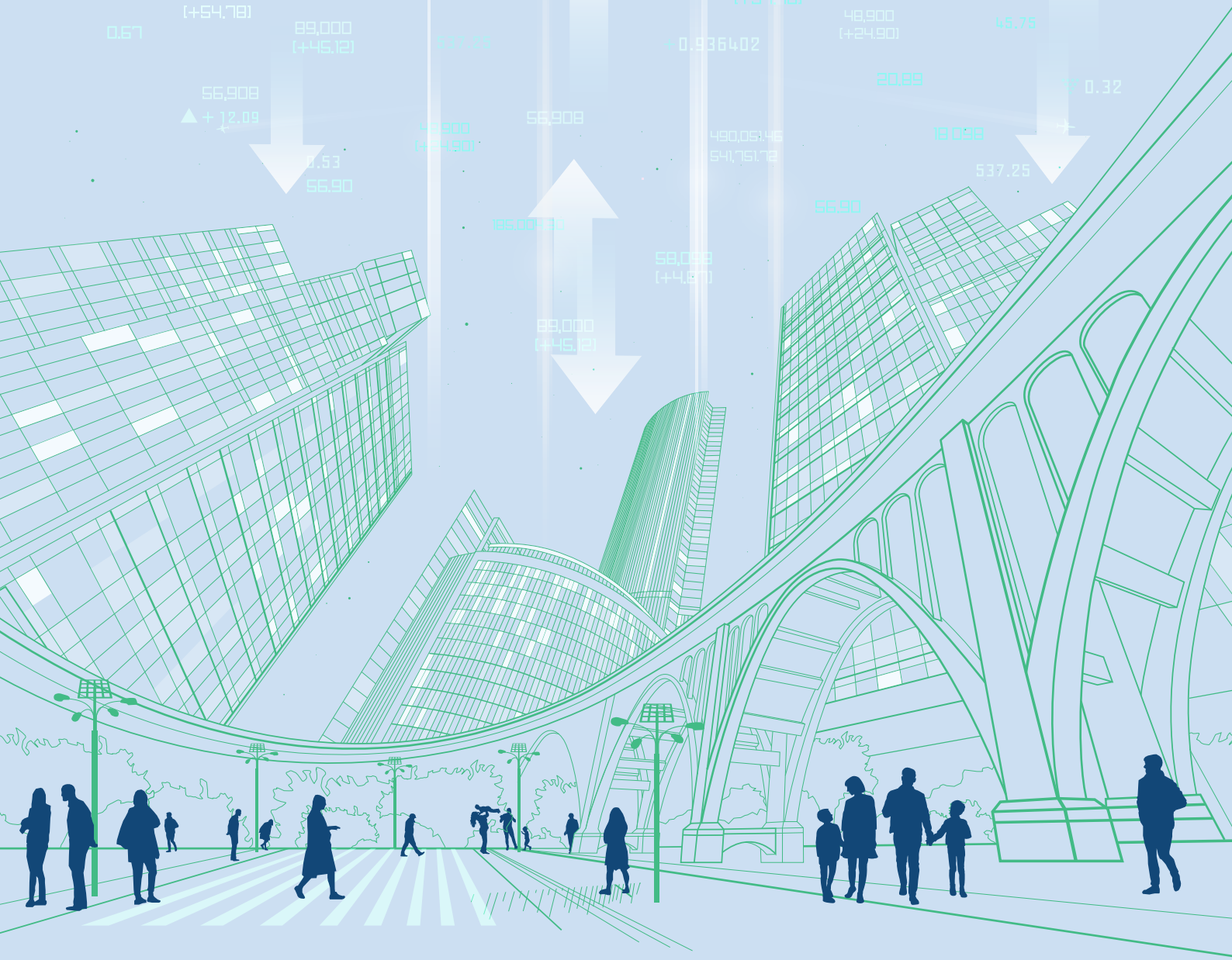
UCLG ASPAC
United Cities and Local Governments Asia-Pacific

ASEAN MAYORS FORUM

UNCDF

Smart Urban Green Practices in ASEAN:

An Assessment of Best Practices in Malaysia, Vietnam and Indonesia



October 2024

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I. Executive Summary

Urban expansion in South-East Asia has been characterised by rapid growth and uneven regional distribution. As of 2020, half (50.1 per cent) of the ASEAN region's population was urban, and this figure is projected to rise to 55.6 per cent in 2030, a total of almost 405 million people. The growth of cities across ASEAN has been associated with increased prosperity and connectivity. However, it has also created challenges such as traffic congestion, pollution, environmental degradation, inequality, and other rapid or uncontrolled growth symptoms. Yet, with the right strategies and collective effort, these challenges can be overcome, paving the way for a more sustainable and prosperous future.

Local governments are well aware of the aforementioned environmental challenges. However, addressing the complex and numerous difficulties inherent in environmental sustainability proves to be a daunting task. Limited financial resources and incomplete data frequently hampered local governments in this area. To bridge this critical knowledge and resource gap, this publication plays a crucial role in providing local governments with practical insights for dealing with the complex challenges of Air Pollution and Clean Urban Transportation Solutions, Renewable Energy and Energy Efficiency, and Water and Sanitation.

This research methodically outlines seven outstanding best practices collected from various ASEAN member states, with a strong emphasis on Malaysian, Vietnamese, and Indonesian experiences. These best practices, developed through a collaborative effort between UCLG ASPAC and UNCDF, are helpful reference points for other local governments looking for successful solutions to fight the aforementioned complicated issues. Among these practices are initiatives such as providing incentives and parking rebates for electric vehicles (EVs), implementing smart-grid projects, introducing rainwater harvesting systems in schools, the Central Mekong Delta Region Connectivity project, the Can Tho Waste-to-Energy project, rainwater harvesting in Vietnam's Mekong Delta, and the establishment of the Likupang Solar Power Plant. These case studies provide practical insight and motivation for local governments looking to improve, and they are part of the region's Smart Green ASEAN Cities Programme.

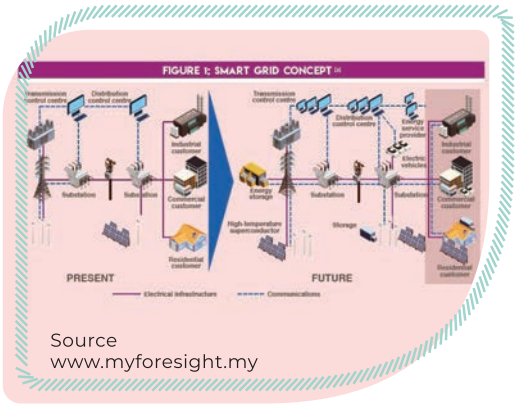
Incentives and Parking Rebates for Electric Vehicles (EV)

The prioritisation of green transportation initiatives is the main point of strategic execution in Hang Tuah Jaya. The primary goal is to increase the use of public transportation equipped with electric vehicles (EVs) and hybrid technologies, reducing dependency on traditional fossil fuels. Concurrently, a concerted effort is to escalate the adoption of clean energy sources. green transportation incentives have been implemented to promote these ecologically conscious endeavours. The Municipal Council of Hang Tuah Jaya (MPHTJ) offers a 50 per cent discount on parking stickers for EV or hybrid technology automobiles. Furthermore, a provision for electric buses traversing the MPHTJ authority increases sustainable mobility further within the territory.

Source
melaka.sinchew.com.my

Smart-Grid Projects

Hang Tuah Jaya, a unique planned area in the Malaysian state of Malacca, stands out as the state's administrative centre and smart city with economic, social, infrastructural, and recreational developments. It is the sole landlocked municipality in the state, a distinction that sets it apart. Malacca, leading national innovation, is integrating smart-grid technology into its high-tech city initiative. Selected among 28 cities for the Smart Grid Demonstration Project, Malacca aims to position itself as a sustainable city, reducing greenhouse gas emissions and increasing renewable energy reliance. Managed by the Housing and Local Government Ministry and the Malaysian Industry-Government Group for High Technology (MIGHT), the project underscores Malacca's commitment to environmental sustainability and technological advancement.



Source
www.myforesight.my

Rainwater Harvesting Systems in Schools

The Hang Tuah Jaya Low Carbon Eco-Schools Programme has launched a project to help reduce and manage water usage in school buildings. All educational institutions in the city have received financial assistance, which aligns with the programme's primary goal of reducing carbon footprint and improving water management efficiency. This strategic programme helps achieve environmental sustainability and strongly emphasises raising student awareness, recognising it as an investment for the future. The programme strives to instil a sense of responsibility and eco-consciousness within the student population through this coordinated effort while actively tackling resource conservation and sustainable practices within the educational landscape.


Source
www.greengrowthasia.org

Can Tho Clean Air Action Plan

The Can Tho City People's Committee, a key player in environmental initiatives, has approved the Action Plan for Can Tho Clean Air until 2025. This comprehensive plan aims to improve air quality and achieve strategic development goals. It includes raising public awareness, improving air quality monitoring, and reducing emissions from various sources. The plan also focuses on raising awareness among policymakers and developing innovative solutions. It includes increasing public transportation use, banning straw burning, and developing industrial parks. Can Tho's participation in the Climate & Clean Air Coalition's BreatheLife campaign further underscores its commitment to a cleaner environment.

Can Tho Waste-to-Energy

The Waste-to-Energy project in Can Tho uses advanced technology to manage domestic waste efficiently. Located in the Trong Xuan commune, it processes 400 tonnes of waste daily, generating 150,000 kilowatt-hours of power. The facility also has a monitoring system for air quality, dust levels, and environmental indicators. This initiative aims to shift Can Tho's waste management towards sustainable practices, aligning with global best practices and contributing to a cleaner, more energy-efficient urban landscape.

Rainwater Harvesting in Vietnam's Mekong Delta

The Mekong Delta region in Vietnam faces a water supply crisis, and household-level rainwater harvesting is a potential solution. Rooftop rainwater collection systems, common in South-East Asia, are cost-effective and scalable, making them suitable for village and district-level water supply initiatives. Improving sewerage and greywater sanitation systems is also crucial, as it reduces surface water pollution and enhances freshwater quality, contributing to a more sustainable water supply.

The Likupang Solar Power Plant

A painstakingly designed network of 64,620 solar panels spans a vast 29-hectare field in Wineru Village, located in the East Likupang district of the North Minahasa Regency in the province of North Sulawesi. Vena Energy installed this solar panel installation, which has been functioning as a new source of electrical energy since September 5, 2019. Despite an installed capacity of 21 megawatts-peak (MWp), the Likupang Solar Power Plant (PLTS) routinely distributes 15 megawatts of power daily. The Likupang Solar Power Plant begins electricity production at 05.30 WITA daily and steadily increases to a peak of 15 megawatts as the sun reaches its zenith. Notably, the plant's output drops when the weather is gloomy, potentially reaching as low as 3 megawatts during rainy seasons. This solar energy effort contributes significantly to the region's electrical grid and highlights the practicality and adaptability of solar technology in the search for sustainable energy solutions.

II. About UCLG ASPAC

The United Cities and Local Governments (UCLG) is a worldwide association of local governments and the officially recognized voice of local governments by the United Nations. UCLG was established on 1 January 2004 and is headquartered in Barcelona, Spain. UCLG is an amalgamation of the International Union of Local Authorities (IULA), United Towns Organization (UTO), and the World Association of the Major Metropolises (METROPOLIS) set up in Ghent (Belgium) in 1913 in Aix-les-Bains (France) in 1957, and in Paris (France) in 1985, respectively.

Following this unification, UCLG ASPAC was established in Taipei on 14 April 2004 as the new entity of IULA ASPAC. UCLG ASPAC's Secretariat is hosted by the Jakarta Provincial Government. UCLG ASPAC is the largest regional section of UCLG. It has links to more than 10,000 cities and local governments, and represents well over 3.76 billion people – more than half of the world population – and incorporates economically fast-developing countries such as China, India, and Indonesia.

UCLG ASPAC is the key knowledge management hub on local government issues in Asia-Pacific. It promotes democratic local government, supports cooperation between cities, local governments and their associations, and facilitates programs, networks and partnerships to develop the capacity of local governments and associations. Moreover, UCLG ASPAC represents local governments politically within the international community and with the United Nations and its agencies. It also promotes inclusive societies that safeguard equality, social and economic justice, and sustainable community development.

In the wider context, UCLG ASPAC works closely with cities and partner organizations, to promote various aspects of people's well-being including local economic development, public spaces, disaster risk reduction, climate change, gender equality, SDGs localization, and overall urban development.

III. About UNCDF

UNCDF mobilizes and catalyses an increase in capital flows for SDG impactful investments to Member States, especially Least Developed Countries, contributing to sustainable economic growth and equitable prosperity.

In partnership with UN entities and development partners, UNCDF delivers scalable, blended finance solutions to drive systemic change, pave the way for commercial finance, and contribute to the SDGs. We support market development by enabling entities to access finance in high-risk environments by deploying financial instruments, mechanisms and advisory.

IV. About the SGAC Project

The Smart Green ASEAN Cities (SGAC) is a European Union (EU)-funded program implemented by UNCDF in partnership with the ASEAN Secretariat in Jakarta, Indonesia.

SGAC works with subnational governments to catalyze financing from the private sector and design innovative financing mechanisms to address environmental and climate change impacts. Through seed financing grants and technical and capacity development support, the program aims to identify green and smart city solutions and design appropriate financing mechanisms in collaboration with local governments. The SGAC-supported projects will contribute reducing the environmental and carbon footprints through smart solutions enabled by digitalization and the use of technologies.

The ASEAN region leads in innovation and success stories with projects addressing environment and climate change at the local levels. Simultaneously, cities and mayors are equally championing the need for more funds and investments to finance their smart and green initiatives. The gap in resources has led to subnational governments exploring other opportunities and partnerships.

In this regard, the SGAC program engages with the cities to:

1. Support design, planning and implementation of green and innovative city solutions in selected cities
2. Strengthen national capacity for green and smart city development through EU-ASEAN experience sharing
3. Increase the exchange of good smart and environmental city management practices between the EU and ASEAN Cities

The SGAC program is implemented in the eight ASEAN member states (Cambodia, Indonesia, Malaysia, Thailand, Laos, Vietnam, Philippines, and Myanmar) in close collaboration with the National Focal Points of the ASEAN Working Group on Environmentally Sustainable Cities (AWGESC), which is supported by the Environment Division of the ASEAN Secretariat in Jakarta.

V. Table of Contents

VI. List of Acronyms

ABS	AssetBacked Securities
ADB	Asian Development Bank
ADD	Alokasi Dana Desa (Village Fund Allocation)
AMDAL	Analisis Mengenai Dampak Lingkungan Hidup (Environmental Impact Assessment)
AMI	Advanced Metering Infrastructure
ASEAN	Association of South-East Asian Nations
BLT	Build-Lease-Transfer
BNM	Bank Negara Malaysia
BOO	Build-Own-Operate
BOT	Build-Operate-Transfer
BOOT	Build-Own-Operate-Transfer
BTO	Build-Transfer-Operate
CAA	Clean Air Act
CAP	Climate Action Plan
DSP	Five Super Priority Destinations
EE	Energy Efficiency
EFT	Ecological Fiscal Transfer
EV	Electric Vehicle
GBI	Green Building Index
GDP	Gross Domestic Product
GEF	Global Environment Facility
GESI	Gender Equality and Social Inclusion
GII	Government Investment Issues
IIGF	Indonesia Infrastructure Guarantee Fund
IPP	Independent Power Producer
JICA	Japan International Co-operation Agency
JVA	Joint Venture Agreement
LDC	Least -developed countries
LEED	Leadership in Energy and Environmental Design
MDBs	Multilateral Development Banks
MDTIDP	The Mekong Delta Transport Infrastructure Development Project
MGS	Malaysian Government Securities
MIGHT	The Malaysian Industry-Government Group for High Technology

MITC	Melaka International Trade Centre
MPHTJ	Majlis Perbandaran Hang Tuah Jaya (The Municipal Council of Hang Tuah Jaya)
MSW	Municipal Solid Waste
MTB	Malaysian Treasury Bills
MW	Megawatt
MWp	Megawatt-Peak
OECD	Organisation for Economic Cooperation and Development
OJK	Otoritas Jasa Keuangan (The Financial Services Authority of Indonesia)
PDS	Private Debt Securities
PFI	Private Finance Initiative
PLTS	Pembangkit Listrik Tenaga Surya (Solar Power Plant)
PPA	Power Purchase Agreement
PPP	Public-Private Partnership
SDGs	Sustainable Development Goals
SMEs	Small- and medium-sized enterprises
SEZ	Special Economic Zone
SOE	State-Owned Enterprise
SO_2	Sulfur Dioxide
SWOT	Strengths, Weaknesses, Opportunities, Threats
TNB	Tenaga Nasional Berhad
TSP	Total Suspended Particles
UKAS	
UNCDF	United Nations Capital Development Fund
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organisation
USAID	United States Agency for International Development
UTO	United Towns Organisation
VGF	Viability Gap Fund
WtTE	Waste-to-Energy

VII. List of Figures

VIII. List of Tables

IX. Acknowledgement

We would like to extend our sincere gratitude and appreciation to the communities, local authorities, and stakeholders of Hang Tuah Jaya, Can Tho, and North Minahasa for their invaluable contributions and profound insights into the urban smart green practices being implemented in their cities.

Their dedication to sustainable development and local governance and their commitment to improving the quality of life for their residents have been inspiring and instrumental in shaping the findings and recommendations presented in this report.

The case study is developed under the Smart Green ASEAN Cities (SGAC) programme, a significant initiative funded by the European Union and implemented by the United Nations Capital Development Fund (UNCDF) in collaboration with the ASEAN Secretariat. This initiative aims to support subnational governments in designing and implementing innovative financing mechanisms for sustainable urban development and climate resilience.

Source-www.unsplash.com

Source Photo by Pok Rie
www.pexels.com/photo/private-houses-and-roads-in-town-2412728

1.0 Introduction

1.1 Addressing Climate Change, Environmental Pressures, and Urbanisation Challenges in the ASEAN Region

The ASEAN region is currently at a critical juncture, grappling with the urgent issues of rapid urbanisation and the escalating impacts of climate change and environmental pressures. As urban areas continue to expand in terms of economic activity and population, the imperative to confront and manage the intricate interplay between urbanisation and environmental sustainability becomes increasingly urgent.

ASEAN countries have witnessed an unprecedented urban shift, with a significant population moving to cities for economic opportunities. The rapid urbanisation is marked by infrastructure expansion, burgeoning industrialisation, and the proliferation of urban sprawl. As cities grow, they metamorphose into both economic powerhouses and sources of environmental strain, underscoring the crucial need for meticulous planning to harmonise the benefits of urban development with the imperative of environmental sustainability.

The ASEAN region is particularly vulnerable to climate change's effects, ranging from extreme weather events and increasing sea levels to agricultural disruptions. Urban centres, often situated in coastal areas, face the dual challenge of adapting to changing climate conditions while mitigating their contributions to greenhouse gas emissions. The increased frequency and intensity of typhoons, floods, and heatwaves require resilient urban infrastructure and sustainable land-use planning to enhance the region's capacity to weather the storms of a changing climate.

Addressing the ASEAN region's climate change, environmental constraints, and urbanisation demands integrated solutions that traverse sectoral lines. A complete strategy must include sustainable urban design, green infrastructure development, and climate-resilient technologies. Furthermore, regional collaboration and knowledge exchange can multiply the impact of individual initiatives, establishing a collective commitment to the ASEAN region's resilient, low-carbon, and ecologically sensitive urban landscapes.

1.2 Relevance and Objectives

Rapid urbanisation and economic expansion within the ASEAN region have created considerable urban difficulties. Environmental sustainability and the need to address the adverse effects of urbanisation, such as air pollution, energy consumption, and water management, are among the most pressing of these concerns. The importance of this best practices report is significant, given the region's rising urbanisation, which calls for practical solutions to ensure that urban growth is environmentally responsible, sustainable, and resilient. In this context, the report highlights the urgent need to find and spread best practices to steer ASEAN cities towards a more sustainable and environmentally friendly future.

This best practices report on smart urban green practices in ASEAN aims to give policymakers, urban planners, and local authorities a comprehensive and insightful resource. Its specific objective is to identify, document, and highlight exemplary initiatives and strategies in three distinct thematic areas: addressing air pollution and developing clean urban transportation solutions, advancing renewable energy and improving energy efficiency, and managing water resources and sanitation effectively. These practices are presented to facilitate their adoption and successful implementation by other key urban stakeholders. This research also highlighted the financial schemes used by the cities to bring their initiatives to reality. The report also looked at additional financing alternatives for each country in the last chapter, ranging from equity to debt instruments.

The report aims to stimulate and advocate for sustainable urban development within ASEAN cities by distributing these best practices. It not only focuses on projects that effectively solve important environmental concerns and improve the quality of life for residents but also serves as a platform for the exchange of knowledge. This enables local governments in the ASEAN region to draw upon their regional counterparts' valuable experiences and accomplishments, fostering collaboration, the sharing of innovative ideas, and the widespread adoption of proven strategies. The report underscores the importance of this collaborative approach in achieving sustainable urban development.

In a broader context, this report aligns with the global agenda for sustainable urbanisation and environmental stewardship. It portrays ASEAN as a leader in implementing creative and sustainable urban practices by emphasising the region's commitment to ecologically responsible urban development.

1.3 Methodology

This publication utilised both qualitative and quantitative methods, incorporating multiple case studies to achieve a comprehensive and structured understanding of the strategies employed by local governments in addressing complex environmental challenges through best practices. By integrating these approaches, the report offers a clear, data-driven foundation to assess the real-world impacts of these initiatives. This Best Practices Report methodology also incorporates SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis to gain valuable insights into each city's planning efforts. This structured framework systematically evaluates internal and external performance factors, guiding decision-making toward optimal outcomes. The practicality of the SWOT analysis reassures the reader about the applicability of our findings to real-world scenarios.

A well-structured methodology is essential in creating a comprehensive and insightful best practices report. This narrative covers the methods used to collect, analyse, and report on the best practices employed by a city. The research employs a methodology integrating primary and secondary data sources to understand the subject matter thoroughly. To begin, selecting a city within the domain of interest is critical. The sample's diversity guarantees a well-rounded representation of the practices under consideration, ensuring that all perspectives are justified. The collection of primary data comprises acquiring first-hand knowledge from the chosen city. This approach involves interviews with key personnel and stakeholders, enabling us to explore the daily operations, challenges, and achievements of these initiatives. The secondary data were chosen based on previously established green smart urban practice themes and were limited to cities in the ASEAN region. These secondary data were then reviewed, including published reports, papers, and existing case studies, which is invaluable in supplementing primary data.

To deliver a comprehensive exposition for each initiative, it is imperative to understand the technical aspects, complexity, sustainability, and outcomes associated with each. Qualitative interviews are a critical component of this methodology, providing direct insights and perspectives that allow readers to delve deeply into the practices, experiences, and strategies adopted by the city under examination. This narrative outlines our approach to conducting and leveraging qualitative interviews for this endeavour, emphasising their role in providing a nuanced understanding of the initiatives.

Before the interviews, a meticulously crafted interview guide is constructed, characterised by its comprehensiveness, flexibility, and strict alignment with the study's objectives. The questions are thoughtfully framed to stimulate in-depth responses, fostering deep reflection from the interviewees. These qualitative interviews are conducted using virtual platforms to ensure accessibility and flexibility. With full consent from the interviewees, the interviews are recorded to preserve the richness and integrity of the collected data. Throughout the process, emphasis is placed on open-ended inquiries, active listening, and skilful probing for profound insights.

The data collected from the interviews undergo rigorous thematic analysis. The interview transcripts are meticulously reviewed, coded, and categorised based on recurring themes and patterns. This analysis serves as the foundation for identifying a SWOT analysis. Furthermore, the qualitative data and insights of these interviews are integrated with other sources, such as secondary data and case studies. This comprehensive synthesis contributes to a holistic and nuanced understanding of the best practices under examination.

Table 1: SWOT Analysis Framework

The qualitative interview findings are incorporated into the report. This report aims to provide a vivid and detailed representation of the experiences, challenges, and innovative approaches unearthed through the interviews. It offers a well-rounded perspective enriched by the voices and experiences of those at the forefront of these best practices.

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Source Photo by Julito Elizalde
www.pexels.com/photo/melaka-mile-sign-with-malaysian-flag-28544950

2.0 Best Practices Overview

This section will examine and evaluate the current initiatives within cities to address challenges related to air pollution and clean urban mobility solutions. This assessment will include detailed city profiles, issues and problems, and solutions.

Table 2: Overview of the Initiatives

Country	City	Thematic Area	Initiatives
Malaysia	Hang Tuah Jaya	Air Pollution and Clean Urban Transport Solutions	Incentive and Parking Rebate for EV
		Renewable Energy and Energy Efficiency	Smart-Grid Project: Smart-meter
		Water and Sanitation	Rainwater Harvesting in School
Vietnam	Can Tho	Air Pollution and Clean Urban Transport Solutions	Can Tho Clean Air Action Plan
		Renewable Energy and Energy Efficiency	Can Tho Waste to Energy Project
		Water and Sanitation	Rainwater Harvesting in The Vietnamese Mekong Delta
Indonesia	North Minahasa	Renewable Energy and Energy Efficiency	Solar Power Plant Likupang (PLTS Likupang)

2.1 Hang Tuah Jaya, Malaysia

Hang Tuah Jaya, a newly constituted municipal entity in Malacca, Malaysia, is a city of significant scale. As the state capital among four local councils, it is home to a population of 190,529 people spread across 144.61 square kilometres. Recognising its importance, the state government has ambitious plans to develop Hang Tuah Jaya into a dynamic cosmopolitan centre. This vision encourages substantial growth in business, society, infrastructure, and recreation. The territorial borders of Hang Tuah Jaya, carefully delineated, originate from segments of three distinct districts: Alor Gajah, Jasin, and central Malacca.

Hang Tuah Jaya, the first eco-friendly city in Malacca, is leading the way in sustainable urban development. Its pilot project, Low Carbon City @ Hang Tuah Jaya 2014, is a pioneering initiative that spans both governmental and residential zones. The city's commitment to sustainability is evident in its adherence to demanding building grading certificates such as the Green Building Index (GBI), Leadership in Energy and Environmental Design (LEED), Green Star, Green Mark, and the Melaka Green Seal. This effort places Hang Tuah Jaya at the forefront of the global movement towards a low-carbon future.

2.1.1 Air Pollution and Clean Urban Transportation Solutions

Problem Overview

Hang Tuah Jaya, a developing Malaysian municipality, passionately strives for a future distinguished by sustainable and eco-friendly transportation. While the city is making commendable progress in this direction, it is not immune to the issues of shifting to a more sustainable transportation infrastructure. Hang Tuah Jaya is grappling with the urgency of establishing and expanding its public transportation infrastructure, as current limitations in comprehensive and efficient public transportation options may contribute to continued reliance on conventional, less sustainable modes of transportation, exacerbating issues such as traffic congestion and air pollution.

Hang Tuah Jaya, amidst its pursuit of sustainable transportation solutions, contends with an existing urban mobility landscape marked by conventional vehicles, traffic congestion, and associated air pollution. The reliance on traditional modes of transportation adds significantly to pollution emissions, thus impacting air quality in the region. The challenges of sustainable transportation in Hang Tuah Jaya directly impact the city's air pollution levels. The continuous usage of conventional automobiles and the slower-than-desired adoption of electric and environmentally friendly alternatives contribute to elevated levels of pollutants, such as particulate matter and greenhouse gases, affecting overall air quality.

Solution

Incentive and Parking Rebate for EVs

The programme aims to make electric vehicles (EVs) more appealing and accessible to private vehicle owners and business enterprises by offering cash incentives and parking rebates. In 2018, Hang Tuah Jaya launched a comprehensive and forward-thinking programme to encourage the use of EVs. It includes several strategic components to encourage EV adoption and promote a more sustainable transportation ecosystem.

Hang Tuah Jaya, as a low-carbon city, is undeniably making significant efforts to minimise pollution and promote sustainable urban mobility. The objective is to increase the use of

electric and hybrid technology in transportation. Hang Tuah Jaya is currently developing incentives to encourage ecologically friendly transportation choices as part of this endeavour. They are intended to lower the environmental imprint and incentivise and compensate residents who choose cleaner and more sustainable modes of transportation. The distribution of parking stickers with a 50 per cent discount specifically adapted for electric and hybrid vehicles is one of the most significant efforts by the Hang Tuah Jaya Municipal Council (Majlis Perbandaran Hang Tuah Jaya, MPHTJ). This strategic policy encourages the use of ecologically friendly transportation and gives a practical incentive to responsible vehicle owners, demonstrating the city's commitment to fostering cleaner, low-carbon solutions. Furthermore, Hang Tuah Jaya is working hard to introduce electric buses that will service the areas within the jurisdiction of MPHTJ. This foresight reduces emissions and helps create a more efficient and sustainable public transit system accessible to all residents.

At the core of this initiative lies a commitment to provide financial incentives to prospective EV buyers. They include direct subsidies, tax credits, and rebates on electric vehicle purchases. The existing incentive and parking rebates for EVs in Hang Tuah Jaya include a parking discount of half the regular rate for EV owners. Hang Tuah Jaya aims to democratise access to this eco-friendly mode of transportation by lowering the initial cost of EVs, making it more affordable and accessible to a broader community. The parking rebate, a unique concept that delivers significant reductions in parking rates to EV owners in the city, is a notable aspect of the programme. This dual-purpose initiative not only actively pushes the use of electric vehicles but also provides a real benefit to vehicle owners, making EV ownership a more cost-effective and convenient option. In parallel, Hang Tuah Jaya has embarked on an extensive expansion of its charging infrastructure. This plan entails strategically placing charging stations throughout the city to ensure EV customers have access to dependable and convenient charging facilities. The city's determination to build an extensive and easily accessible charging station network demonstrates its commitment to EV adoption.

Hang Tuah Jaya's holistic approach, blending financial incentives, the innovative parking rebate, and extensive charging infrastructure, signifies more than a commitment to reducing its carbon footprint. It reflects the city's ambition to construct a sustainable and environmentally responsible transportation ecosystem. This foresight represents the city's pledge to a cleaner, greener future and frames EV ownership as an enticing and practical option for both residents and visitors. Hang Tuah Jaya's efforts serve as a shining example of progressive urban planning and sustainability, a model for cities seeking to encourage more environmentally friendly and accessible transportation alternatives.

Project Assessment

Strengths

Government Support

Hang Tuah Jaya's incentives and parking rebates for electric vehicles (EV) programme is a strategic initiative promoting sustainable transportation. The programme is supported by government agencies, demonstrating a commitment to sustainable urban mobility. The city's leadership is committed to mitigating environmental damage and promoting eco-friendly commuting. The programme's significance is highlighted by its alignment with broader government sustainability goals, as articulated in The Low Carbon Mobility Blueprint 2021-2030, a comprehensive strategy aimed at evaluating the most effective methods for energy and greenhouse gas (GHG) reduction in Malaysia's transportation sector, particularly land transportation. This blueprint aims to reduce transportation

emissions, currently the country's second-largest source of CO_2 emissions after the energy sector, accounting for 25 to 30 per cent of total GHG emissions, primarily from internal combustion engine (ICE) vehicles. As Malacca's first eco-friendly metropolis, Hang Tuah Jaya integrates sustainable transit into its development fabric, inspiring trust among people, businesses, and investors. Government support is seen as a pathfinder towards a cleaner, greener future.

Financial Incentives

Hang Tuah Jaya is dedicated to sustainable urban mobility, offering parking rebates and financial incentives to encourage the adoption of EVs. This approach addresses the upfront cost barrier and makes EV ownership financially realistic, matching individual budget concerns. The programme's multimodal strategy increases EVs' economic attractiveness, making them environmentally ethical and financially sensible choices. By making electric vehicles more affordable, Hang Tuah Jaya encourages immediate adoption and lays the foundation for a long-term, profitable ecosystem that lives harmoniously with the environment.

Alignment to International Sustainability Standards

Hang Tuah Jaya is committed to creating a sustainable, eco-friendly urban landscape that meets global environmental standards. It incorporates GBI, LEED, and Green Star benchmarks, demonstrating a global desire for environmental excellence. This comprehensive approach sets a precedent for other communities seeking environmentally responsible urban settings. The city's commitment to international standards inspires joint efforts. It serves as a hub for information exchange and collaboration, helping to build a global network of cities committed to improving sustainable urban development. The city's extensive approach to sustainability is a testament to its dedication to environmental excellence.

Weaknesses

Limited Awareness

Hang Tuah Jaya faces a challenge in promoting eco-friendly commuting due to a lack of awareness among citizens about EVs and their incentives. The transition to sustainable mobility requires a paradigm shift in understanding, as EVs serve as environmental and economic messages. Awareness of the benefits of cleaner air, lower environmental impacts, and long-term cost savings is crucial. By highlighting these benefits, the city can inspire a collective realisation of the benefits of EVs and their incentives. Strategic awareness initiatives can help Hang Tuah Jaya become a catalyst for change, promoting a community that actively embraces the transformative potential of sustainable mobility.

Charging Infrastructure Challenges

With a heavy focus on charging infrastructure, Hang Tuah Jaya aims for an environmentally sustainable future for urban mobility. In order to attract potential customers for EVs, it is vital to address issues around restricted availability and coverage of charging stations. The term "range anxiety" refers to the dread citizens and companies have when there are few charging stations for electric vehicles. As of 2017, Hang Tuah Jaya has just two charging stations available for electric vehicles, which may limit their mobility.

Upfront Costs of EVs

Despite attractive incentives, the initial pricing barrier for electric vehicles remains a significant obstacle. According to a Tenaga Nasional Berhad (TNB) study, driving an EV in Malaysia can be between 11.4 per cent to 28.3 per cent cheaper than petrol vehicles using RON 95. Due to higher upfront costs, EV ownership may be financially out of reach

for budget-conscious buyers. Hang Tuah Jaya, a city focusing on a sustainable future and affordable EV ownership, is addressing this challenge by incorporating measures like parking rebates and financial incentives.

Opportunities

Growing EV Market

Hang Tuah Jaya is strategically shifting towards sustainable mobility. The city recognises the strategic potential of promoting EV adoption to lower greenhouse gas emissions, improve air quality, and foster a climate-conscious community. As the global market for electric vehicles expands, Hang Tuah Jaya presents itself as an economic player, investing in infrastructure, driving EV adoption, and cultivating a supportive ecosystem. This approach lays the groundwork for an environmentally responsible economic growth.

Advancement in Technology

The city of Hang Tuah Jaya is embracing the future of electric vehicles with improved battery life and charging speeds. These advancements can pave the way for a future where current restrictions are no longer barriers but stepping stones towards development. Hang Tuah Jaya recognises the importance of increased battery life, which allows EVs to travel farther on a single charge, making them more practical and appealing to a broader user base.

Expanded Charging Infrastructure

The city has developed a charging infrastructure to ensure a seamless experience for EV users, removing barriers to widespread adoption. Strategically placed charging stations give EV owners confidence in long-distance travel and a sense of freedom. This network encourages residents and businesses to embrace EVs, contributing to a greener, more sustainable community.

Threats

Competing Technologies

Hang Tuah Jaya is not just embracing alternative clean technologies, but also challenging the dominance of EVs in the sustainable urban development landscape. The city is incorporating hydrogen fuel cell vehicles into its sustainable urban development goals, and considering advances in combustion engine efficiency. These efforts, aimed at reshaping the sustainable transportation sector, will intrigue those interested in the city's innovative approach.

Economic Challenges

Hang Tuah Jaya, a city deeply committed to sustainable urban transportation, is aware of the potential impact of economic downturns and financial uncertainty on the decision to invest in electric vehicles despite incentives like parking rebates. The city recognises the need to balance environmental responsibility and economic interests. To address this, Hang Tuah Jaya is considering financial relief options beyond incentives and parking rebates, including partnerships with financial institutions and government subsidies. The city's incentives framework reflects its dedication to overcoming economic risks and aims to create a sustainable and supportive environment for EV adoption.

Policy and Regulatory Changes

Hang Tuah Jaya is focusing on the long-term viability of its EV incentive plan. The city acknowledges the volatility of the regulatory landscape and its role in ensuring the programme's appeal and stability. The city's EV incentive programme is designed to give citizens and businesses peace of mind. However, the city acknowledges the need for strategic planning and adaptation to regulatory changes. It works with government agencies to share information about the positive effects of EV incentives on the community, environment, and sustainable urban mobility. The city also diversifies incentives to remain attractive and adaptable, incorporating elements resilient to potential changes. Strategic communication is key to this approach, fostering trust and confidence among residents and businesses.

Summary

Hang Tuah Jaya's incentives and parking rebates for electric vehicles (EV) programme is a significant initiative towards sustainable urban mobility. The city's government support and financial incentives are key strengths, but challenges like limited awareness and charging infrastructure issues persist. Opportunities lie in the growing EV market and technological innovations, but threats like competing technologies and economic challenges pose risks. Regardless, Hang Tuah Jaya addresses these issues through strategic initiatives, technological advancements, and adaptability. Overall, its commitment to environmental excellence is commendable.

Table 3: SWOT Analysis Matrix of Incentive and Parking Rebates for EVs

SWOT Analysis Matrix: Incentive and Parking Rebate for EV				
SWOT Assessing Aspects	Strengths	Weaknesses	Opportunities	Threats
	Government Support: MPHTJ supported EV Programme promotes sustainable transport, integrating eco-friendly commuting into urban development, fostering trust among residents and businesses.	**Limited Awareness:** Some consumers may not be aware of the incentives and rebates available for EVs, which could limit the program's effectiveness.	**Growing EVs Market:** To lower carbon footprints, enhance air quality, and develop a community that cares about the environment, Hang Tuah Jaya is encouraging the use of EVs, investing in infrastructure, and promoting sustainable mobility.	**Competing Technologies:** The emergence of alternative transportation options, such as shared mobility services or autonomous vehicles, could reduce the demand for EVs, making incentives and rebates less effective.
	Financial Incentives: By addressing upfront expenses, encouraging ecologically friendly options, and providing parking refunds and financial incentives for EV adoption, Hang Tuah Jaya is fostering sustainable urban mobility.	**Charging Infrastructure Challenges:** The lack of charging infrastructure, including public and home stations, may hinder the widespread adoption of electric vehicles, potentially limiting their practicality for consumers.	**Advancement in Technology:** In order to create a more useful and accessible future, Hang Tuah Jaya is embracing electric vehicles (EVs) with longer battery lives and faster charging times.	**Economic Challenges:** Economic downturns or financial crises could lead to reduced government funding for incentives and rebates, making it difficult for consumers to afford EVs.
	Comprehensive Incentive Programme: As a pioneer in sustainable urban development, Hang Tuah Jaya integrates Green Star, LEED, and GBI standards to encourage eco-friendly living and foster community.	**Upfront Costs of EVs:** Budgetary constraints may limit eligible vehicles and financial assistance, potentially deterring potential buyers from considering electric vehicles due to perceived lack of financial incentives.	**Expanded Charging Infrastructure:** By placing charging stations in key locations, Hang Tuah Jaya is encouraging the adoption of electric vehicles and improving battery life and charging stations	**Policy and Regulatory Changes:** Changes in government policies or priorities could result in the elimination or reduction of incentives and rebates, which could discourage consumers from purchasing EVs.
Conclusion	Hang Tuah Jaya's EV Programme, supported by government and financial incentives, aims for sustainable urban mobility. Despite challenges like limited awareness and charging infrastructure, the city is adapting through strategic initiatives and technological advancements.			

The Policies or Regulation

Hang Tuah Jaya benefits from national and subnational policies supporting incentives and parking rebates for electric vehicles, such as the Low Carbon Cities Framework (LCCF), of which the Hang Tuah Jaya Municipal Council is a constituent. Its primary objectives are to reduce carbon emissions and foster sustainable urban growth. Additionally, at the national level, the Malaysian government has initiated an EV policy to transition towards sustainable energy alternatives and reduce reliance on fossil fuels.

Impact on Gender Equality and Social Inclusion

Implementing incentives and parking rebates for EVs in Hang Tuah Jaya can serve as a catalyst for promoting gender equality and social inclusion by making EVs more affordable and accessible to a wider demographic, including women and individuals with lower incomes, aligning with sustainable transportation goals that benefit the environment and public health.

However, the effectiveness of these measures may depend on the intricacies of policy development and implementation, as not all segments of society may reap equal benefits. The Malaysian government's EV policy, incorporating tax incentives, reduced road taxes, green parking initiatives, toll rebates, and rebates for home charger installations, aims to be inclusive and reach a diverse demographic, particularly women. This commitment extends to various vehicle types and manufacturers, ensuring broad accessibility, especially among those from lower-income backgrounds. It also strives to promote gender equality by encouraging women's employment in the EV sector and supporting their recruitment and empowerment.

A 2023 study by the Pembina Institute indicates that women are less likely than men to purchase EVs, potentially due to factors such as differing car buying habits, income levels, or access to information about EVs. This suggests that incentives and rebates could exacerbate these disparities if not designed with gender equity in mind. To address this challenge, targeted incentives could be tailored to support women in purchasing EVs, such as rebates or subsidies for low-income households, often headed by women, encouraging EV adoption and advancing gender equity by providing more opportunities for women in the market.

Additionally, incentives for charging infrastructure could be designed to ensure accessibility in areas where women are more likely to frequent, such as shops and their workplaces or homes. This would increase their reachability and use, bridge the gender gap in EV adoption, and foster economic empowerment opportunities for women through the growth of EV-related businesses and entrepreneurial ventures.

Funding Sources

The funding for incentives and parking rebates for EVs in Hang Tuah Jaya is allocated through the Municipal Council's budget, although specific figures are not publicly available. In Malaysia's 2024 budget context, Prime Minister Anwar Ibrahim has unveiled significant strategies to encourage investment in EV technology. Key measures include

offering rebates of up to USD 560 for individuals earning USD 28,000 or less annually to purchase electric motorcycles.

The government is also aiming to secure USD 40 million in investments from companies like Tenaga Nasional Berhad (TNB), Gentari, and Tesla Malaysia to establish 180 EV charging stations across the country. Moreover, the budget extends to income tax relief for individuals who spend over USD 580 on EV charging infrastructure by four years and continues tax deductions for EV rentals for two additional years. These initiatives highlight Malaysia's commitment to fostering sustainable transportation.

2.1.2 Renewable Energy and Energy Efficiency

Problem Overview

Hang Tuah Jaya faces challenges integrating renewable energy sources and dealing with environmental issues such as air pollution and greenhouse gas emissions. Adequate integration of renewable energy sources such as solar, wind, and hydro may be hampered by limited infrastructure, finance, and policies. Energy security and supply reliability may also be problematic. Inefficient energy consumption in the household and industrial sectors can result in greater prices and negative environmental consequences.

Solution

Smart-Grid Project: Smart Metre

Hang Tuah Jaya aspires to be a centre for green technology and a world-class smart city. Proposed actions to promote green technology, such as energy efficiency measures, will also contribute to the carbon intensity reduction target of 45 per cent by 2030. The Global Environment Facility (GEF) and the United Nations Industrial Development Organisation (UNIDO) established the Melaka Smart Grid Pilot Project, which served as the smart-grid project's foundation, specifically the setting up of smart metres in Hang Tuah Jaya. The smart grid encompasses a range of innovative technologies, such as sensors, software, and communication devices. These tools provide real-time data on electricity consumption patterns and usage locations. Smart metres, in particular, allow customers and utility providers to monitor energy usage and pricing fluctuations in real time.

The Majlis Perbandaran Hang Tuah Jaya (MPHTJ) supported the undertaking and was the first local council to initiate the pilot project. MPHTJ has already begun implementing low-carbon initiatives, such as installing energy efficiency (EE) equipment and smart metres on commercial buildings as part of an energy-saving effort. The programme aims to transform the town's energy system and make it more reliable, sustainable, and efficient. The installation of cutting-edge smart metres in every residence is the centrepiece of the smart-grid programme in Hang Tuah Jaya. These devices provide real-time data on electricity consumption, going far beyond simple energy metres, enabling residents to monitor and control their usage unlike ever before. The era of approximations and unexpected bills is over, and smart metres have made educated decision-making and energy conservation possible.

Smart metres are state-of-the-art electrical reading contraptions that empower users by collecting daily electricity consumption data. TNB launched an ambitious plan to install Advanced Metering Infrastructure (AMI), often known as smart metres, in about 8.3 million households nationwide by 2021. The smart-grid programme was initiated in 2019, while the district cooling system at the Melaka International Trade Centre (MITC) is still in the design stages. This innovative strategy is prepared for commercial expansion, encouraging the widespread adoption of energy-efficient technologies throughout Melaka, particularly within the limits of Hang Tuah Jaya. The smart-grid programme brought significant economic benefits to the town. Smart metres offer nearly real-time data on energy consumption, allowing consumers to optimise their usage, conserve energy, and decrease expenses by adjusting their consumption patterns, such as aligning usage with fluctuating energy prices. This proactive management could alleviate the necessity for costly peaker plants, thereby lowering energy expenses for individuals and businesses within the town.

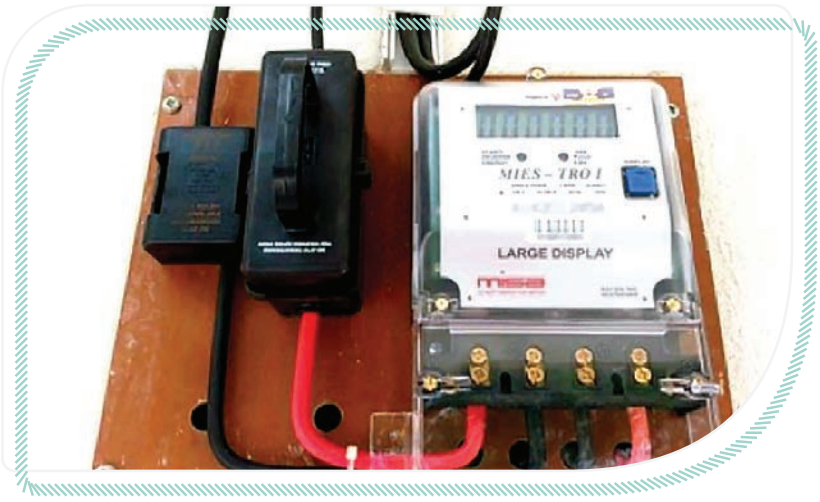

Figure 1: Smart metres application in Hang Tuah Jaya, Melaka
Source: Hang Tuah Jaya Climate Action Plan 2030

Project Assessment

Strengths

Efficient Energy Distribution

A smart grid is a revolutionary energy distribution system that uses advanced technologies and real-time data analytics to optimise electricity flow. It addresses transmission losses, a common issue in traditional grids, by integrating monitoring and control technology, resulting in more generated power reaching end consumers with maximum efficiency. This contributes to the sustainability of the energy infrastructure and improves resource conservation, aligning with global sustainability goals. Implementing a smart grid is crucial today, where reducing environmental impact and improving energy efficiency is a top priority.

Advanced Metering Infrastructure (AMI)

AMI is a novel technology that empowers users with real-time monitoring of their energy consumption habits. It provides users with precise and comprehensive information

about their energy usage, overcoming traditional limitations in providing immediate and granular data. AMI enhances customer awareness and control by supplying a constant data stream, enabling informed decisions about their energy use. It also helps users recognise patterns, detect inefficiencies, and implement more sustainable practices in their daily energy consumption. The installation of smart metres allows for real-time monitoring of energy consumption, enabling consumers to make informed decisions about their energy usage and potentially reduce waste. This technology represents a paradigm shift in energy management and customer interaction, putting the power of energy efficiency in the hands of the consumers.

Data Analytics

The smart grid is a groundbreaking technology in energy management, enabling data-driven intelligence beyond traditional electricity distribution. Its ability to gather and analyse large volumes of data is key to its success, enabling decision-making, predictive maintenance, and energy distribution optimisation. The smart grid's comprehensive data analytics platform provides stakeholders real-time information on energy usage, grid performance, and system vulnerabilities, enabling informed decision-making and shifting from reactive to proactive energy management. Its predictive maintenance capabilities enable utilities to identify faults before they escalate into critical breakdowns, reducing downtime, lowering operational costs, and improving energy infrastructure reliability.

Weaknesses

Technical Challenges

In the energy sector, integrating cutting-edge technology offers ample opportunities for efficiency and innovation. However, specific expertise requirements present significant challenges. Implementing and sustaining smart-grid technology demands diverse technical, engineering, and IT-related skills, which may not be readily available in the local workforce. These include addressing operational inefficiencies, overcoming communication breakdowns, and integrating disparate data sources. Managing such an integrated system requires capable personnel, and a shortage of qualified professionals could present a substantial obstacle. Therefore, developing a comprehensive plan, collaborating with experts, and cultivating a culture of continuous learning are crucial to navigating these challenges effectively.

Interoperability Issues

Without standardised protocols and interfaces, different components of the smart-grid system may struggle to communicate effectively. This issue can lead to interoperability issues where devices from different manufacturers or parts of the grid cannot exchange data or coordinate actions seamlessly. For example, smart metres may not be able to communicate with distribution management systems, and energy storage systems may not integrate well with renewable energy sources.

Limited Private Sector Participation

The limited involvement of the private sector in the smart-grid projects could hinder innovation and efficiency. A lack of active engagement from private sector entities in smart-grid projects may result in decreased investment, impeding the advancement of new technologies and services. Furthermore, the absence of specialised private companies in the smart grid could lead to a deficit in essential

expertise, potentially compromising the efficiency and dependability of the system. It might also cause an ineffective distribution of resources, burdening the government with a more significant financial and operational load. Additionally, the lack of private sector participation may stifle competition within the smart-grid market, reducing innovation and increasing consumer costs.

Opportunities

Enhanced Energy Efficiency

A smart grid is a technology that delivers real-time insights into energy consumption patterns, grid performance, and demand changes, allowing for informed decisions and resource allocation optimisation. It discourages energy waste by recognising inefficiencies and responding to variations in demand. The smart grid encourages a dynamic interaction between supply and demand, reducing system strain during peak hours and fostering a conscientious and sustainable energy consumption culture. Beyond operational efficiency, the advantages include environmental stewardship, which contributes to lower greenhouse gas emissions and ensures a sustainable power supply for future generations.

Support for Renewable Energy Goals

The smart grid represents a revolutionary approach to incorporating renewable energy into existing energy infrastructures. Hang Tuah Jaya intends to invest in photovoltaic (PV) solar energy as part of this renewable energy initiative. The smart grid facilitates the seamless integration of renewable energy sources into conventional energy systems, acting as a dynamic ecosystem. Its capability to manage the flow of renewable energy ensures efficient utilisation and system stability. Real-time adjustments to energy distribution in response to fluctuations in renewable power levels are made possible, addressing challenges and enhancing energy self-sufficiency. Integrating renewable energy aids global efforts toward decarbonisation and sustainable development by reducing greenhouse gas emissions and fostering a cleaner, more environmentally sustainable energy landscape.

Innovation and Research

The smart-grid project in Hang Tuah Jaya is not just a technological advancement but a catalyst for innovation and R&D in the energy sector. It has the potential to inspire groundbreaking progress in energy technology, foster a forward-thinking culture, and provide a fertile foundation for inventive solutions. This project paves the path for a more resilient and sustainable future by promoting collaborations and creative thinking.

Threats

Elevation of Privilege

Elevation of Privilege (EoP) is a type of cyberattack where an intruder exploits vulnerabilities in a system to gain unauthorised access and control over critical components, potentially leading to disruptive and harmful consequences. In a smart-grid system context, EoP can occur when an attacker manipulates the typical sequence of operations within the power grid system, exploiting weak authentication schemes or other vulnerabilities. EoP attacks can have significant consequences, such as access

to sensitive information or control over critical components, potentially disrupting the operation of the power grid system and causing system instability, leading to power outages or other disruptions. In some cases, EoP attacks can physically damage the power grid infrastructure, potentially causing further harm. Implementing modern technology, such as smart grids, necessitates a significant commitment to cybersecurity. Because of their increased interconnection, these systems are vulnerable to various threats, including unauthorised access and sophisticated cyberattacks. A breach can have serious repercussions, damaging essential infrastructure, sensitive data, and public trust. A complex strategy comprising enhanced encryption methods, intrusion detection systems, and continuous monitoring is required to defend the smart grid. Access control, data privacy, and incident response must all be governed by strict policies. Regular training programmes aid in developing a culture of vigilance and security measures.

Public Opposition

The smart-grid project in Hang Tuah Jaya involves collecting and using personal energy consumption data to optimise energy distribution. However, concerns about privacy and potential misuse of this data, such as unauthorised access, breaches, or inappropriate use by utility companies, may lead to public opposition. For instance, in Germany, some consumers have opposed the introduction of smart-grid technologies due to privacy and data protection concerns. This is especially noticeable in the context of smart metres, where critics contend that collecting usage data by energy companies creates privacy concerns and might be used for purposes other than energy management. Open communication, safety standards, and robust privacy protection measures are crucial to building trust and garnering public support.

Summary

Smart-grid technology optimises electricity flow and reduces transmission losses, ensuring more power reaches consumers. It aligns with global sustainability goals by conserving resources. AMI allows users to monitor energy consumption habits, enabling more sustainable practices. The data analytics platform improves operational efficiency and reliability. However, smart grid implementation faces technical challenges like diverse expertise and interoperability issues. Limited private sector participation may hinder innovation. Despite the above obstacles, smart grids offer opportunities to enhance energy efficiency, support renewable energy goals, and foster innovation. Cyberattacks and public opposition must be addressed through robust cybersecurity measures, transparent communication, and community engagement strategies. Successful implementation requires careful consideration of challenges and proactive measures.

Table 4: SWOT Analysis Matrix of Smart-Grid Project

SWOT Analysis Matrix: Smart-Grid Project: Smart-Meter				
	Strengths	Weaknesses	Opportunities	Threats
SWOT Assessing Aspects	**Efficient Energy Distribution:** With the help of cutting-edge technology and real-time data analytics, smart grids can optimise the flow of electricity, reduce transmission losses, and increase energy efficiency—all of which are in line with the objectives of global sustainability.	**Technical Challenges:** The energy sector is integrating advanced technology for efficiency and innovation, but challenges arise due to the need for diverse technical, engineering, and IT skills.	**Enhanced Energy Efficiency:** Real-time energy usage insights are provided by smart grid technology, which also optimises resource allocation, encourages sustainable use, reduces waste, and fosters environmental stewardship.	**Elevation of Privilege:** An attacker can disrupt the power grid system's normal operations, gaining unauthorised access and control over critical components, potentially leading to disruptive and harmful consequences.
	Advanced Metering Infrastructure (AMI): Advanced Metering Infrastructure (AMI) is a revolutionary technology that provides real-time energy consumption monitoring, enhancing customer awareness, enabling informed decisions, and promoting sustainable practices.	**Interoperability Issues:** The smart grid system in Hang Tuah Jaya is not fully standardised, which can lead to interoperability issues and inefficiencies in managing energy supply and demand.	**Support for Renewable Energy Goals:** By combining renewable energy with conventional energy systems, the smart grid ensures system stability and optimal usage, promoting sustainable development and global decarbonisation.	**Public Opposition:** Some individuals may have a lack of trust in the utility companies responsible for implementing and managing smart grid systems, which could lead to resistance to the technology
	Data Analytics: Data-driven intelligence is used by the smart grid to manage energy, allowing for better decision-making, preventive maintenance, and distribution optimisation that lowers operating costs and downtime.	**Limited Private Sector Participation:** Limited private sector involvement in smart grid projects may hinder innovation, efficiency, and competition, potentially causing decreased investment, expertise deficit, and increased costs for consumers.	**Innovation and Research:** A visionary energy sector project aims to drive innovation, optimise resource utilization, and address long-standing issues, fostering collaboration and creative thinking for a more resilient future.	
Conclusion	Energy management is revolutionised by smart grid technology, which is in line with sustainability objectives. Technical difficulties, cybersecurity threats, and community opposition are among the challenges. Regulatory support, community involvement, and innovation are necessary for a holistic strategy.			

The Policies or Regulations

In Malaysia, the National Energy Policy 2022-2040 (NEP) outlines the government's priorities for the energy sector, including promoting renewable energy and implementing smart-grid technologies. The NEP sets targets for increasing the installed capacity of renewable energy, reducing the percentage of coal in installed capacity, and increasing the percentage of electric vehicle share in the country. The government is also investing in grid infrastructure upgrades and energy storage to support integrating renewable energy and the rollout of smart-grid systems.

Impact on Gender Equality and Social Inclusion

The impact of the smart-grid project on gender equality and social inclusion can be significant. It has the potential to maximise impacts on gender equality and women's empowerment by promoting access to affordable energy resources, ensuring women's participation in the ongoing energy transition, and addressing the gender gap in the renewable energy workforce. By integrating a gender- and social-inclusive perspective into the progression of smart grids and renewable energy systems through a Gender Action Plan (GAP), the aim is to ensure women's involvement and benefits

in these endeavours. Simultaneously, this approach monitors and addresses gender-specific impacts throughout the implementation phase. Furthermore, the project has established targets for women's engagement in technical capacity-building activities, aiming for at least 25 per cent participation of women in technical training and roles. Additionally, women have been appointed as national coordinators of the project. This project could eliminate institutional obstacles and amplify incentives, broadening access to energy resources and employment opportunities for diverse groups.

Funding Sources

International Development Funding

The smart-grid project in Hang Tuah Jaya is a significant initiative promoting sustainable energy management. It is funded by the Global Environment Facility (GEF) and the United Nations Industrial Development Organization (UNIDO). The GEF's support of smart-grid systems in Hang Tuah Jaya, as part of the Asia Pacific Economic Cooperation Low-Carbon Model Town (APEC LCMT) Project, including the Smart Grid Project Melaka (Hang Tuah Jaya), is a testament to its commitment to promoting the transfer of renewable energy technologies and reforming policies and rules for this vital sector. The GEF's role likely involves funding and supporting the development of smart-grid systems, which can improve energy efficiency, reduce greenhouse gas emissions, and enhance the overall sustainability of the area's energy infrastructure.

The smart-grid project in Hang Tuah Jaya is a crucial endeavour that has received financial assistance from the GEF through the GEF-UNIDO National Project. The project, which includes installing a smart grid, solar PV, and building energy management systems in Hang Tuah Jaya, is a vital step towards sustainable energy management. The GEF's support of establishing a co-operative network of sustainable cities in the Asia-Pacific region, including the APEC Low-Carbon Energy Efficient Cities and the APEC Sustainable City Service Network, further underscores the importance of this project for Hang Tuah Jaya.

2.1.3 Water and Sanitation

Problem Overview

The Climate Action Plan 2030 by the Hang Tuah Jaya Municipal Council highlights water scarcity as a significant issue, leading to drought, increased resource demand, and risks to vulnerable populations. These issues affect the availability of clean, safe water in schools, which may influence the health and well-being of teachers and students. In order to guarantee that all schools have access to safe and clean water, which is crucial for the education and general well-being of children and teachers, the water shortage in Hang Tuah Jaya must be addressed.

Solution

Rainwater Harvesting in Schools

The Rainwater Harvesting Project for Schools in Hang Tuah Jaya is an innovative project that combines community involvement, education, and environmental sustainability seamlessly. The project's primary goal is to collect rainwater from school rooftops, a significant resource that can be used to lower water bills and provide a platform for education and raising awareness. Firstly, it seeks to implement rainwater harvesting systems across ten carefully selected schools in Hang Tuah Jaya, all falling under the jurisdiction of the Hang Tuah Jaya Municipal Council. This strategic selection ensures the success and widespread impact of the Rainwater Harvesting in School initiative.

Installing rainwater harvesting systems in schools reduces water bills and creates a self-sustaining cycle, where the financial savings are reinvested into the schools for further improvement. While the cost savings are significant, the impact goes far beyond economics. These schools set an example of sustainable water management by using harvested rainwater for tasks such as flushing toilets, cleaning, and irrigation. This approach helps tackle immediate water challenges while embedding sustainable practices into everyday school operations.

Moreover, the project serves as a valuable educational tool. Both students and teachers gain hands-on experience with climate change adaptation and sustainability, making environmental education a core part of the curriculum. This initiative helps cultivate a sense of ecological responsibility in the younger generation, encouraging them to adopt greener practices. The cost efficiency of rainwater harvesting in Hang Tuah Jaya's schools depends on factors like installation costs, water savings, and system maintenance. A medium-sized system, typically used for purposes like flushing toilets, would cost between USD 2,340 and 4,680 to set up.

Water rates in Malaysia, including Hang Tuah Jaya, range from USD 0.13 to 0.18 per cubic metre (m^3). A school that collects and uses about 50,000 litres (or 50 cubic metres) of rainwater per month would save between USD 84 to 113 monthly for water. By the end of the year, the water bill can be as high as USD 1,357, a significant expense for an educational institution. However, the problem is not just about cost. As the region grows and more people rely on treated municipal water, the demand for water continues to rise. Water prices are also expected to increase, meaning this seemingly manageable expenditure could balloon over the coming years. On top of that, there is the possibility of water shortages or restrictions during dry seasons, making it more difficult for schools to access the water they need.

The current situation underscores schools' reliance on external water supplies used for non-essential purposes such as flushing toilets and irrigating gardens – tasks that do not require treated, potable water. It highlights a key opportunity for rainwater harvesting, which offers financial savings and a more efficient approach to water resource management. Schools could significantly reduce their water bills by implementing a system to capture and store rainwater for non-potable uses. Even a modest rainwater harvesting system could cut costs by up to half, resulting in annual savings of USD 490 to 680. These savings could then be reinvested into other school projects, fostering a cycle of continual improvement and sustainability.

Larger systems that capture more rainwater can generate even greater savings, depending on the school's water usage and local rainfall patterns. Water prices will likely rise over

time, so these systems will become even more cost-efficient. Increased rainfall and better use of harvested water will further boost efficiency, making rainwater harvesting a smart long-term investment for schools.

Figure 2: Rainwater Harvesting in Schools
Source: Green Growth Asia Foundation, 2018

Project Assessment

Strengths

Cost Savings

Rainwater harvesting systems address rising costs from traditional water sources, reducing water bills and mitigating financial strain. Implementing these systems can lead to significant cost savings, allowing for redirected funds toward core educational priorities. Schools can reduce their monthly water bills significantly by utilising rainwater for non-potable purposes such as flushing toilets, watering gardens, or cleaning. Schools in Hang Tuah Jaya have traditionally relied on municipal water for everything – flushing toilets, cleaning, and watering gardens – tasks that do not need treated water. For a school with around 1,000 students and 100 staff, this means using about 630,000 litres of water each month, which costs the school between USD 90 and 113. Over the year, that adds up to a hefty bill of USD 1,000 to 1,355. However, with the introduction of rainwater harvesting systems, things are changing for the better. By collecting and using rainwater for non-drinking purposes, schools can reduce their water consumption by around 50 per cent. This small but impactful change has cut their water bills in half, saving them about USD 42 to 56 monthly, or between USD 490 and 680 per year. The long-term economic viability of these systems is bolstered by their resilience and adaptability to climatic conditions in Hang Tuah Jaya, ensuring sustained financial benefits over an extended period.

Educational Opportunities

Schools in Hang Tuah Jaya are launching a rainwater harvesting programme to promote water conservation and environmental responsibility. This programme is more than just a practical solution; it is also a bold commitment to education. It functions as a living laboratory, integrating academic knowledge with practical application. Students obtain a comprehensive awareness of the connection between human actions and the environment, fostering a feeling of environmental stewardship and natural resource sensitivity.

Community Engagement

The schools' rainwater harvesting initiative is a community movement involving students, teachers, parents, and local authorities. Launched in 2018, it aims to involve up to 28 schools adopting environmentally friendly practices. The initiative emphasises stakeholder engagement, fostering a shared sense of responsibility towards sustainability. Education plays a crucial role, with programmes like the Digital Climate Change Marathon, organised by the MPHTJ and Green Growth Asia Foundation, empowering young people with the knowledge and tools to advocate for change within their communities. It also encourages community-based environmental undertakings like urban farming and composting, enriching community practices and nurturing a culture of sustainability. The project collaborates with universities like Universiti Pertanian Malaysia to enhance the effectiveness of the rainwater harvesting systems. This initiative aligns with Hang Tuah Jaya's climate action goals, promoting collective growth and sustainability.

Weaknesses

Maintenance Challenges

Rainwater harvesting systems' operational success depends on their ongoing operation, and frequent maintenance is critical for their longevity and effectiveness. Routine inspections are conducted to identify and address issues, ensuring the optimal condition of components such as collection surfaces, storage tanks, and distribution mechanisms. However, maintaining these systems poses challenges. Each school is responsible for upkeeping its rainwater tanks, which requires regular cleaning and monitoring. Often, this task falls to the school staff or local community volunteers. Unfortunately, maintenance can be inconsistent, relying heavily on available resources and training. Many staff members may not have the expertise needed for effective system management, which can lead to inefficiencies.

There are several areas for improvement to maximise the benefits of rainwater harvesting. For instance, comprehensive training programmes could be implemented to equip school staff and students with the necessary skills for regular maintenance. Encouraging greater community involvement can also facilitate a sense of collective responsibility towards these systems, emphasising their importance for water conservation. Moreover, consistent monitoring and evaluation of the water quality and system performance could help identify potential issues before they escalate. This proactive approach ensures that the systems remain functional and beneficial to the schools. Finally, support from local authorities in the form of resources and funding could significantly enhance the effectiveness of these rainwater harvesting initiatives. Periodic maintenance protects against unforeseen breakdowns and extends the lifespan of the infrastructure, optimising the return on investment. A well-executed maintenance programme improves system reliability, predictability, and sustainability while serving as a learning tool for students and the community.

Limited Scope

The schools are implementing rainwater harvesting systems to mitigate water scarcity risks due to variable weather patterns, particularly during drought or low rainfall. The systems' capacity depends on rainfall availability and efficacy. A comprehensive approach includes water conservation practices, storage management, and educational campaigns.

Alternative water sources during low rainfall have been considered. Expanding the project could help address regional water scarcity.

Technical Expertise

As part of their commitment to sustainability, the schools are implementing rainwater harvesting systems. Difficulties, however, have arisen due to the necessity for specialised technical competence in design, implementation, and maintenance. The design needs a thorough understanding of hydraulic engineering, climate factors, and school infrastructure requirements. The installation process demands building, plumbing, and system integration knowledge, which may not be available at the schools. Regular maintenance is essential for the rainwater harvesting system's longevity and effectiveness.

Opportunities

Demonstration Site

The schools have the potential to function as model sites to present effective rainwater harvesting techniques, thereby motivating other establishments and community members to adopt similar initiatives. By showcasing the installation and execution of rainwater harvesting infrastructure, including methods like rooftop collection, storage tank usage, and filtration systems, they can illustrate practical implementation strategies. Additionally, a school can collect data on various aspects of the rainwater harvesting process, such as the quantity of rainwater collected, its utilisation for non-potable purposes, and the resultant savings on water expenses. This data can then be disseminated to other schools and institutions, facilitating their understanding of the benefits and feasibility of rainwater harvesting initiatives.

Collaborations and Partnerships

The Hang Tuah Jaya Local Council and the Green Growth Asia Foundation (GGAF) have been instrumental in advancing the Rainwater Harvesting in Schools project and promoting the adoption of similar initiatives by other educational institutions. This partnership has yielded various outcomes, including GGAF's workshops and training sessions geared towards equipping teachers and students with the necessary knowledge and skills for implementing rainwater harvesting systems within their schools. Their support has been crucial in their successful implementation in schools across Hang Tuah Jaya.

Additionally, GGAF has worked alongside the Hang Tuah Jaya Local Council to support schools in enhancing their sustainability through the Low Carbon Eco-Schools (LCS) workshop. Through this programme, schools are guided in harvesting rainwater from their rooftops to reduce water expenses, educating students about climate change, raising public awareness on rainwater harvesting, and sharing their experiences with other organisations. Moreover, GGAF has leveraged this collaboration with the Hang Tuah Jaya Local Council to inform teachers of Melaka's green initiatives and the pivotal role schools play in mitigating carbon emissions. This exposure has led to the certification of schools as eco-schools, fostering sustainable practices and raising awareness of environmental issues.

Water Security

The schools, as leaders in water security projects, are implementing rainwater harvesting systems to reduce reliance on external water sources and create a reserve for emergencies. This effort also seeks to develop a culture of responsible water

management in students, educators, and community members. By placing the schools at the forefront of water security initiatives, they inspire a shared responsibility for water security that transcends individual interests. This commitment to improving water security sets an example of hope and resilience, contributing to the community's long-term growth.

Threats

Clogging

Clogging is common in rainwater harvesting systems, particularly in the gutters and downpipes. Debris, such as leaves, twigs, and sediments, can accumulate, affecting water quality and reducing the system's efficiency. It is crucial that the gutters be cleaned at least every six months, and the filter basket should be inspected routinely to remove any debris that may have accumulated. The "leaf eater" or any other debris-collecting components should be cleaned regularly to maintain the system's performance. This regular maintenance is a proactive step towards ensuring the system's efficiency and water quality.

Dependency on Rainfall

The effectiveness of a rainwater harvesting programme is strongly dependent on rainfall, which requires an innovative and adaptable strategy. Understanding local climate trends and utilising technology such as weather monitoring systems can assist in the development of a responsive system that maximises advantages during times of abundance and optimises usage during periods of scarcity. The educational component of this method creates an adaptive and responsible water management mindset, urging people to be more considerate of their water usage. The challenge of implementing a rainwater harvesting programme is not a limitation but an opportunity for innovation and creativity, fostering environmental consciousness within the community.

Regulatory Compliance

Regulatory compliance for rainwater harvesting systems in schools involves adhering to local regulations and standards that govern their installation, maintenance, and use. Conformity is crucial to ensure the safety and effectiveness of the systems and avoid potential legal and financial consequences. In Malaysia, regulatory compliance for rainwater harvesting systems is primarily managed by the Ministry of Energy, Green Technology, and Water, which is responsible for setting and enforcing energy and water conservation standards. The Energy Commission and the National Water Services Commission regulate the energy and water sectors, respectively. The regulatory framework in Malaysia includes guidelines and standards for energy efficiency in buildings, water and sewerage quality, and plumbing. For example, the Malaysian Guidelines for Energy Efficiency in Buildings provide voluntary standards for non-residential buildings, covering envelope, lighting, and HVAC systems. Similarly, the National Standard for Drinking Water Quality sets parameters for drinking water quality, which water suppliers must comply with.

For rainwater harvesting systems specifically, compliance with regulations may involve obtaining necessary permits, ensuring proper installation and maintenance, and adhering to water quality and treatment guidelines. It can include regular inspections and testing to ensure the systems function correctly and safely. While regulatory accordance can be time-consuming and costly, it is essential for ensuring the integrity and effectiveness

of rainwater harvesting systems in schools. This not only protects the health and safety of students and staff but also helps maintain the reputation and credibility of the school and avoid potential legal and financial liabilities.

Summary

Hang Tuah Jaya schools are adopting rainwater harvesting systems for cost savings, educational opportunities, and community engagement. These systems provide a living laboratory for environmental responsibility and stewardship, fostering community engagement. As demonstration sites, schools play a crucial role in showcasing effective techniques and promoting collaborations with local councils. Water security measures are being implemented to reduce reliance on external sources and instil responsible water management. Threats include clogging, dependency on rainfall, and regulatory compliance. Despite these challenges, the commitment to rainwater harvesting in schools signifies a proactive approach towards sustainability and community resilience. These initiatives aim to create a more water-secure and environmentally conscious future for all stakeholders through collaboration, innovation, and education.

Table 5: SWOT Analysis Matrix of Rainwater Harvesting in Schools Project

SWOT Analysis Matrix: Rainwater Harvesting in School				
	Strengths	Weaknesses	Opportunities	Threats
SWOT Assessing Aspects	**Cost Savings:** Because of their durability and climate adaptability, rainwater harvesting systems in Hang Tuah Jaya's schools lower water costs, save water bills, and support long-term economic viability.	**Maintenance Challenges:** Rainwater harvesting systems require frequent maintenance for longevity and effectiveness. Schools face challenges in allocating resources for inspections, but well-executed maintenance improves system reliability, predictability, and sustainability.	**Demonstration Site:** The school can serve as a model for implementing effective rainwater harvesting techniques, demonstrating practical implementation strategies and collecting data to inform other institutions.	**Clogging:** The accumulation of dirt, leaves, and other debris on the roof can clog the gutters and downpipes, reducing the amount of water collected and stored
	Educational Opportunities: Hang Tuah Jaya schools are combining academic knowledge with real-world application by introducing a rainwater harvesting programme to encourage water conservation and environmental responsibility.	**Limited Scope:** Rainwater harvesting systems are typically used for non-potable purposes, such as irrigation, cleaning, and washing. They may not be suitable for drinking water or other potable uses without additional treatment	**Collaboration and Partnerships:** The Hang Tuah Jaya Local Council and Green Growth Asia Foundation are collaborating to advance the 'Rainwater Harvesting in School' project, offering workshops, training, and support for schools to enhance sustainability and raise environmental awareness.	**Dependency on Rainfall:** Rainwater harvesting relies on rainfall, which can be unpredictable. In areas with low or irregular rainfall, the system may not provide a consistent supply of water
	Community Engagement: Rainwater harvesting movement in Hang Tuah Jaya, involving local stakeholders, promotes sustainable practises and ethical resource management, involving simulation modeling for school tank volumes.	**Technical Expertise:** The school is implementing rainwater harvesting systems for sustainability, but faces challenges due to specialised technical competence in design, implementation, and maintenance.	**Water Security:** The school is implementing water security measures, including rainwater harvesting systems, to promote sustainable and water-resilient futures, fostering responsible water management among students, educators, and community members.	**Regulatory Compliance:** Regulatory compliance for rainwater harvesting systems in schools is crucial to ensure safety, effectiveness, and avoid legal and financial consequences.
Conclusion	Hang Tuah Jaya schools are implementing rainwater harvesting systems for cost savings, education, and community engagement, despite challenges like maintenance and technical expertise.			

The Policies or Regulations

Although considered a relatively recent phenomenon in Malaysia, rainwater harvesting is hardly mentioned in local laws on water resource management. Despite this, various agencies address related issues through regulations, such as land development control, falling under the jurisdiction of the Town and Country Department. Amendments to the Town and Country Planning Act of 1976 may be necessary to accommodate this. Additionally, water quality enforcement is divided between the Department of Environment and the Department of Local Government, suggesting a potential need for revisions to the Environmental Quality Act 1974 and the Local Government Act 1976. The Department of Local Government, responsible for planning approval and urban drainage, may require assessments under the Street, Drainage and Building Act 1974. Implementing mandatory rainwater harvesting demands a thorough examination of these acts. Nevertheless, the Hang Tuah Jaya Climate Action Plan 2030 aims to integrate rainwater harvesting and greywater recycling into new developments for non-potable usage.

Impact on Gender Equality and Social Inclusion

The Hang Tuah Jaya schools' rainwater harvesting project has the potential to influence social inclusion and gender equality significantly. Rainwater collection programmes can empower women and vulnerable groups by giving them a voice in decision-making and leadership responsibilities and providing opportunities for skill development. The rainwater harvesting project will benefit both men and women by offering a reliable source of water and assisting in developing resilient communities better equipped to handle the challenges of climate change and water scarcity.

Funding Sources

Government Grants

The Hang Tuah Jaya Rainwater Harvesting in Schools initiative receives funding from a low-carbon governance grant provided by the Ministry of Environment and Water (KASA). The Hang Tuah Jaya Local Council and the Green Growth Asia Foundation (GGAF) have partnered up for the Rainwater Harvesting in School initiative to promote sustainable water management in schools across the Hang Tuah Jaya region. The project's objectives include collecting rainwater from school rooftops to lower water expenses, educating students about climate change, enhancing public understanding of rainwater harvesting, and sharing the water harvesting experience with other organisations. GGAF has conducted workshops and training sessions to empower teachers and students with the expertise and abilities required to install rainwater harvesting systems in their schools.

2.2 Can Tho, Vietnam

Can Tho is a bustling city located in the lower region of the Mekong River Delta, approximately 169 kilometres from Ho Chi Minh City. It is known for its floating markets, rice paper-making village, and picturesque rural canals. As of 2024, the population of Can Tho is estimated to be 1,939,000. Since 2009, Can Tho has been directly controlled

by the central government. Geographically, Can Tho plays an important role within Vietnam and the larger Mekong Delta region. This territory has considerable economic prospects, but it also faces several challenges. Can Tho also plays an important role in driving the socioeconomic growth of the Mekong Delta region, with development goals for 2020 and 2030 planned to maximise this effect. The city aggressively promotes economic growth, cultural enrichment, and scientific and technological advancements, which would benefit the region.

2.2.1 Air Pollution and Clean Urban Transportation Solutions

Problem Overview

According to the Clean Air Act (CAA), the sources of air pollution in Vietnam are multifaceted and caused mainly by industry, transportation, coal-fired power stations, and home use of solid fuels. Traffic is the most significant contributor to air pollution in Can Tho. Monitoring data from 2011 to 2015 show that the city's air quality has been contaminated, mainly by total suspended particles (TSP) and noise levels. Between 2020 and 2025, emissions, including SO_2, are expected to rise by more than 30 per cent and dust by nearly 20 per cent in Can Tho. The high number of motorbike-oriented transportation in Can Tho threatens air quality and restricts the movement of those who are more vulnerable. The urgent need for improved infrastructure and alternative transportation options is evident, especially during flood seasons when the city's heavy reliance on road networks makes it vulnerable to disruptions.

The region's waterways, surprisingly underutilised, hold significant potential to enhance economic and passenger travel. The 40,400 square kilometres of the Mekong Delta region, including Can Tho, offer great potential for agricultural production and attracting investment in various businesses. However, the slow pace of transit infrastructure development has repressed this potential for a long time. Overcoming this barrier could lead to a brighter economic future for Can Tho and the region, fully capitalising on their inherent strengths and maximising their advantages.

Solution

Clean Air Action Plan (CAAP)

Can Tho has carried out a Clean Air Action Plan (CAAP) to address air pollution and promote the adoption of clean urban transportation solutions. Emphasising the importance of monitoring air quality and decreasing emissions from significant sources, such as transportation and industry, the CAAP was approved by the Can Tho City People's Committee in April 2019. Since then, it has steered the city towards fulfilling its commitment to meeting various air quality standards outlined by the World Health Organization (WHO), particularly regarding fine particles and other harmful air pollutants.

Over its five-year duration, the CAAP is set to offer clear guidance and a detailed strategy for enhancing air quality across the city. The CAAP in Can Tho operates by establishing distinct air quality targets, emphasising preventive and mitigative actions, delineating the responsibilities of various sectors and stakeholders, ensuring accountability, implementing reporting and monitoring mechanisms, and is supported by a financial

and investment plan. This plan aims to enhance air quality by integrating air quality considerations into urban development, closely monitoring air quality, and mitigating emissions from key sources, particularly transportation and industry.

Can Tho has recognised the need for measures to mitigate air pollution and proposed solutions that address this issue. They include advocating for public transportation and limiting individual modes of transportation to minimise emissions. The city is committed to encouraging the adoption of public transportation as an alternative to motorbikes and private cars. The CAAP also proposes banning post-harvest straw burning in the surrounding countryside. To ensure the effectiveness of these measures, the plan includes the installation of automatic and continuous transmission systems to monitor air quality and exhaust emissions within and outside the city boundary.

As part of the plan, the city has been considering the implementation of a bus rapid transit (BRT) network to reduce reliance on private vehicles and promote cleaner forms of public transportation. Endorsed by numerous international organisations, the BRT system is expected to be implemented, thereby aiding in reducing air pollution and easing traffic congestion. It is anticipated to significantly reduce the number of private vehicles on the road, leading to improved air quality and reduced traffic congestion, thereby enhancing the overall liveability of the city. The city has also been working on improving the capacity of local authorities and partners to implement the plan and improve air quality in the city.

Project Assessment

Strengths

Mainstreaming Air Quality Concerns in Urban Development

Can Tho's CAAP is a comprehensive strategy that integrates air quality concerns into various aspects of urban development, including planning, transportation, industry, and energy, aiming to address air pollution issues holistically at the city level. Developed collaboratively with Clean Air Asia, a leading regional air quality management network, and executed through the Integrated Programme for Better Air Quality in Asia, a multi-stakeholder initiative to improve air quality in Asian cities, the CAAP outlines specific actions to enhance air quality while aligning with strategic development goals. Leveraging data from emissions inventories and air quality modelling projects, the plan focuses on strengthening public transportation, promoting non-motorised transportation, and integrating co-benefits of air pollution and climate change mitigation, focusing on raising awareness and active stakeholder participation.

Air Quality Modeling

The air quality modelling of Can Tho's CAAP is an essential collaborative effort to the plan. It aims to improve air quality and help the city achieve its strategic development goals. CAAP incorporates air quality modelling results to understand better the impact of air pollution on the local environment and guide decision-making. This modelling is a crucial aspect of the CAAP, aiding in identifying pollution sources, gauging their extent, assessing health impacts, and evaluating the effectiveness of various mitigation strategies. Its results are based on the emissions inventory results of the GIZ Clean Air for Smaller Cities in ASEAN Project and include air quality modelling from the Establishing Air Pollution Propagation Model and Building Solutions to Protect the Air Environment for Sustainable Development of Can Tho City project. The modelling process helps identify key air quality issues and ensures effective responses to address them.

Community Engagement

The plan underscores the potential impact of individual actions in raising public awareness and promoting behavioural changes to enhance air quality. It advocates for community involvement through campaigns to clean the environment, collect and treat waste, and promote sustainable practices. Inclusive learning sessions are organised, bringing together community leaders and members to deliberate on local air quality and climate concerns, including problems like metal waste, charcoal and wood usage for cooking, industrial and vehicular emissions, pesticide application, and construction activities. This direct community engagement is deemed crucial for effectively addressing air pollution. The plan aims to promote behavioural shifts among the public by adopting sustainable practices, such as utilising public transportation, reducing reliance on motorcycles and private vehicles, and avoiding post-harvest straw burning in the surrounding countryside. These adjustments are deemed pivotal for reducing emissions and enhancing air quality, and each individual's contribution is crucial in this collective effort.

Weaknesses

Limited Public Awareness

A weakness of the CAAP involves limited public awareness and engagement, potentially leading to a lack of comprehension and support for the plan's objectives and targets. To address this weakness, Can Tho has initiated measures to enhance public awareness regarding air pollution and its impact on climate and public health. The city has implemented diverse action programmes to improve awareness and involve the public in addressing air pollution issues. These efforts include collaborating closely with the health sector to integrate air quality considerations into urban development and highlighting the mutual benefits of reducing air pollution for health, climate change mitigation, and economic development.

Additionally, the city organises town-hall meetings, community gatherings, and public events to update residents on proposed significant development initiatives, air monitoring initiatives, and various strategies to mitigate health impacts from exposure to air pollution. However, further efforts may be necessary to ensure comprehensive public engagement throughout the planning and implementation phases of the CAAP.

Resistance to Change

The CAAP's acknowledgement of the significant challenge posed by resistance to change in implementing behavioural changes that contribute to air quality improvement is a crucial validation of the concerns of all involved. The plan's recognition that some individuals or groups may resist changes to their daily habits or behaviours, which could limit the effectiveness of the plan's behavioural change strategies, is a key starting point for our collective efforts. People often develop habits based on convenience, cost, or cultural norms, making it difficult to change their behaviour, especially if the alternatives are perceived as less convenient or more expensive. Also, social and cultural norms can influence behaviour, and some individuals may resist changes against these norms.

For example, in some cultures, motorbikes are a standard mode of transportation, and changes to public transportation might be seen as less convenient or less prestigious. Additionally, economic factors can influence behavioural changes, such as the cost of alternatives or the perceived benefits of maintaining the status quo. For instance, some individuals might resist altering their transportation habits if they perceive public transportation as less affordable or convenient.

Inadequate Monitoring and Evaluation

The CAAP might lack adequate monitoring and evaluation systems to observe progress and pinpoint areas for enhancement. This deficiency could result in a lack of accountability and transparency in executing the plan. The potential impact of this lack of robust monitoring systems is significant, as it is difficult to accurately assess the effectiveness of outlined initiatives, hindering the ability to measure reductions in pollutant levels, evaluate the impact of implemented measures on air quality, and identify emerging pollution sources. Urgent action is needed to address this issue.

Moreover, insufficient evaluation mechanisms may hinder identifying and resolving barriers or challenges encountered during CAAP implementation. Without timely feedback on strategy performance, making informed decisions about necessary adjustments or refinements to enhance efficacy becomes complicated. Without transparent monitoring and evaluation processes, there may also be a lack of public confidence in the CAAP's ability to deliver tangible improvements in air quality. It can undermine support from stakeholders and impede the mobilisation of resources necessary for successful plan implementation.

Opportunities

Collaborations with the Health Sector

The involvement of the health sector is not just crucial but also promising in shaping and executing CAAPs. Collaboration between health and other sectors can effectively address air pollution through various policies, plans, and initiatives. By addressing air pollution, CAAPs foster economic advancement, enhance public health, reduce healthcare costs, and promote sustainable economic growth. A joint effort with the health sector aids in pinpointing opportunities for economic progress while improving air quality, offering a hopeful future for all.

For instance, initiatives focused on promoting green technologies and sustainable industries generate employment prospects and stimulate economic expansion while reducing harmful emissions. Moreover, investments in healthcare infrastructure and services aimed at addressing air pollution-related health issues contribute to economic development by enhancing the population's overall well-being. Additionally, CAAPs can include health impact assessments to identify the potential health effects of air pollution and guide the development of effective air quality management strategies.

Technological Advancements

The CAAP highlights the importance of technological advancements in air quality monitoring and management, assuring the audience of the plan's effectiveness. The plan aims to leverage these advancements to enhance the city's ability to monitor and manage air quality, ensuring that the city's air quality improvement initiatives are informed by the most up-to-date and reliable data available. The plan includes expanding automatic monitoring stations – particularly in areas with dense population – industrial parks and main road intersections. This expansion will provide more comprehensive and real-time data on air quality, enabling the city to respond more effectively to air pollution issues.

The plan incorporates air quality modelling results from the Establishing Air Pollution Propagation Model and Building Solutions to Protect the Air Environment for Sustainable Development of Can Tho City project. It helps understand key air quality issues and identify the most effective measures to address them. The plan can utilise advanced

data analytics and visualisation tools to process and present the data collected from the monitoring stations and other sources. It will enable the city better to understand patterns and trends in air quality, identify improvement areas, and track its initiatives' effectiveness. By incorporating these technological advancements, the CAAP can ensure that its air quality improvement initiatives are grounded in the most accurate and reliable data available, leading to more effective and sustainable solutions for the city's air quality challenges.

BreatheLife Network

The BreatheLife Network is a global campaign led by the WHO, the Climate & Clean Air Coalition, and the government of Norway to raise awareness about the health risks of short-lived climate pollutants (SLCPs) and air pollution. The campaign aims to bring air quality to safe levels by 2030 and collaborate on clean air solutions to achieve this target. Can Tho is the first city in Vietnam to join the campaign, demonstrating its commitment to addressing air pollution and improving air quality for its residents. As a member of the BreatheLife Network, Can Tho will receive assistance from the WHO, including aid worth USD 30,000, to carry out communication activities to raise public awareness of air pollution and support for addressing issues related to urban waste and renewable energy. The city's comprehensive CAAP focuses on reducing significant emission sources, particularly transportation and industry, to improve its residents' quality of life and protect the environment. By joining the network, Can Tho can learn from other cities and countries and contribute to developing clean air solutions that will help achieve the 2030 target.

Threats

Urbanisation and Industrialisation

The rapid urbanisation and industrialisation of Can Tho present urgent and significant challenges to the city's air quality. The increasing number of vehicles on the road, industrial activities, and construction sites are leading to a surge in air pollution. This results in higher emissions of pollutants like particulate matter, nitrogen dioxide, and sulfur dioxide, posing a direct threat to the health of residents and exacerbating the city's air pollution issues. The rapid urbanisation and industrialisation are driven by the city's economic growth and the need for infrastructure development, but they also demand immediate attention to curb the escalating air pollution.

Additionally, the city's industrial sector has been expanding, with many factories and industrial parks being established, contributing to air pollution. The CAAP acknowledges the importance of managing urbanisation and industrialisation effectively to mitigate the negative impacts on air quality. The plan includes measures such as increasing the use of public transportation, promoting green industry development, and locating industrial parks away from the city centre. These measures aim to reduce the number of vehicles on the road and minimise the impact of industrial activities on air quality.

Lack of Enforcement

The CAAP is aware of the importance of enforcement in ensuring the plan's effectiveness in reducing air pollution. The plan stresses the need for strict application of regulations and policies to reduce air pollution, particularly in emissions control and waste management. Non-compliance can lead to a lack of significant emissions reductions, which is crucial to air quality improvement. Lack of enforcement and compliance can erode public

trust in government and regulatory agencies, making it harder to implement effective environmental policies in the future.

Summary

The CAAP, a comprehensive strategy to combat air pollution in urban development sectors, places a strong emphasis on public and non-motorised transportation and climate change mitigation. The plan underscores the role of community engagement and sustainable practices. However, it faces challenges such as limited public awareness and resistance to change. Overcoming these challenges through collaboration with the health sector and technological advancements is crucial to the plan's success. Can Tho's participation in the BreatheLife Network further demonstrates its commitment to clean air solutions.

Table 6: SWOT Analysis Matrix of the Clean Air Action Plan (CAAP)

SWOT Analysis Matrix: Clean Air Action Plan				
	Strengths	Weaknesses	Opportunities	Threats
SWOT Assessing Aspects	**Mainstreaming Air Quality Concerns in Urban Development:** Can Tho City's Clean Air Action Plan integrates air quality concerns into urban development, focusing on public transportation, non-motorized transport, and climate change mitigation, promoting active stakeholder participation.	**Limited Public Awareness:** Although the plan emphasises the importance of raising public awareness, there may be challenges in effectively communicating the importance of air quality and encouraging behavioral changes that contribute to improved air quality	**Collaboration with Health Sector:** .By addressing air pollution, the health sector can work with other sectors to develop and deliver on Clean Air Action Plans, leading to co-benefits for health, climate change, and the economy	**Urbanisation and Industrialisation:** Can Tho's rapid urbanisation and industrialisation are causing air pollution due to increased traffic, industrial activities, and construction sites. This leads to higher emissions of pollutants like particulate matter, nitrogen dioxide, and sulfur dioxide. The city's economic growth and infrastructure development have contributed to this issue.
	Air Quality Modeling: Can Tho City's Clean Air Action Plan utilises air quality modeling to improve air quality and achieve strategic development goals.	**Resistance to Change:** The Can Tho Clean Air Action Plan acknowledges resistance to change, as people may resist behavioral changes due to convenience, cost, or cultural norms, and economic factors, such as perceived benefits of maintaining the status quo.	**Technological Advancements:** The Can Tho CAAP utiliSes technological advancements for accurate air quality monitoring and management. It expands automatic monitoring stations, incorporates air quality modeling, and uses advanced data analytics to track progress and identify areas for improvement.	**Lack of Enforcement:** Non-compliance can lead to insufficient emissions reductions and erode public trust, making future environmental policies more challenging.
	Community Engagement: The plan emphasises public awareness and behavioral changes to improve air quality, involving community involvement in campaigns, waste management, and sustainable practices. It encourages sustainable transportation and reducing emissions.	**Inadequate Monitoring and Evaluation:** Can Tho City's Clean Air Action Plan (CAAP) lacks robust monitoring and evaluation systems, potentially causing accountability issues and a lack of transparency, hindering effective implementation, identifying barriers, and boosting public confidence.	**BreatheLife Network:** Can Tho City, Vietnam's first city to join the BreatheLife Network, is committed to raising awareness about air pollution and achieving safe levels by 2030. The city will receive aid and support for public awareness and clean air solutions.	
Conclusion	Can Tho City's Clean Air Action Plan aims to combat air pollution in urban areas through public transport, non-motorized transport, and climate change mitigation, despite challenges like limited public awareness.			

The Policies or Regulations

Vietnam has implemented several policies and regulations to support the CAAP and address air pollution issues. Notable among them is the National Action Plan on Air Quality Management introduced in 2016, which entails stricter regulations on new vehicle emission standards, improved traffic control measures, enforcement of dust management protocols at construction sites and during transportation, heightened monitoring of industrial emissions, and bans on the use of charcoal stoves in urban areas. Additionally, Vietnam's 2014 Environmental Law mandates air quality management requirements, such as point source registration, emissions inventory, and the installation of continuous emission monitoring systems for primary stationary sources of emissions. In 2021, the Prime Minister of Vietnam outlined six objectives in Decision No. 1973/QD-TTg, which include finalising the framework, policies, and regulations concerning air quality management, mitigating emissions, and fostering communication, education, and capacity-building efforts related to air quality management.

Impact on Gender Equality and Social Inclusion

The CAAP, in its mission to address gender equality and social inclusion, places a strong emphasis on community engagement. By promoting and empowering local mechanisms to address air quality and climate change issues, the plan ensures that the community is not just a recipient of the initiatives but an integral part of their success. The involvement of community-based organisations, often women-led, in discussions and decision-making processes related to air pollution mitigation measures, as well as the encouragement of women and the youth in awareness-raising initiatives, ensures that these efforts are inclusive and multisectoral. The plan also supports the implementation of localised, participatory Clean Air Plans with representatives from marginalised groups, including rubbish scavengers, to ensure that their concerns and solutions are considered in developing air quality and climate change strategies. This approach not only ensures that marginalised communities' needs and perspectives are considered, but also makes the community feel involved and integral to the success of the CAAP.

Funding Source

International Development Funding

The CAAP is funded by Clean Air Asia, working alongside the Ministry of Natural Resources and Environment through the Vietnam Environment Administration. The plan was part of the Integrated Programme for Better Air Quality in Asia. Clean Air Asia, collaborating with governments and organisations across Asia to enhance air quality, likely played a key role in funding or securing funds for the plan. Their website lists various donors, including the Asian Development Bank, the World Bank, and USAID. Originally launched as the Clean Air Initiative for Asian Cities (CAI-Asia). The CAAP also possibly received financial support from the Vietnamese government through the Ministry of Natural Resources and Environment or the Vietnam Environment Administration.

2.2.2 Renewable Energy and Energy Efficiency

Problem Overview

A study by Okayama University found that Can Tho generated an average daily per capita of 0.29 kg of household solid waste in 2010, with biodegradable products accounting for 82 per cent and recyclable goods accounting for 10 per cent. In 2014, Can Tho transitioned to a new waste treatment plant, the Phuoc Thoi Waste Treatment Plant, which was built as a temporary open landfill with manual combustion procedures that did not meet hygiene standards. The city initiated the construction of a comprehensive solid waste treatment facility in Phuoc Thoi ward to address environmental challenges. The lack of standardised technical norms in landfills and the environmental consequences of dumping practices, such as water contamination and greenhouse gas emissions, have led to water contamination problems, emphasising the need for sustainable waste management practices.

Solution

Can Tho Waste-to-Energy

Nestled in the heart of the Mekong Delta region, the Can Tho Waste-to-Energy (WtE) is a remarkable symbol of innovative sustainable practices. The Can Tho WtE was conceived to revolutionise waste management in the Mekong Delta. With its innovative approach, it handles the critical issue of garbage disposal and taps into the waste's latent potential. The plant is intended to turn home waste into a valuable resource – power – while minimising the environmental impact of typical waste disposal methods. Since commencing operation in December 2018, the plant has maintained a strong commitment to environmental care. It has successfully handled over 400,000 metric tonnes of domestic waste over the years, diverting it from landfills and incineration. It not only alleviates the pressure on landfills but also minimises hazardous pollutants.

At the same time, the Can Tho WtE contributed a staggering 113 million kilowatt-hours of renewable energy to the national electricity grid. This facility's significance goes beyond waste management and clean energy production. It has been a driving force for long-term development in the Mekong Delta. The factory illustrates the region's dedication to circular economy concepts by converting waste into a profitable resource. It conserves resources and bolsters the local economy by creating new employment and opportunities. The Can Tho WtE has empowered the region by implementing sustainable practices and positively impacting the community. It has improved the quality of life for residents by eliminating waste-related environmental hazards and generating a cleaner living environment. Furthermore, the facility's operation emphasises the importance of appropriate waste management and energy generation.

Figure 3: Can Tho Waste-to-Energy Project in Thoi Lai District
Source: Ministry of Industry and Trade of The Socialist Republic of Vietnam, 2021

Project Assessment

Strengths

Environmental Sustainability

Waste-to-energy plant projects are crucial for environmental sustainability, transforming municipal solid waste into a valuable energy resource. Since the initiation of the Can Tho WtE project in December 2018, they have limited landfill waste by diverting waste from landfills and reducing landfill overflow. The facility handles approximately 400 tonnes of household waste daily, reducing landfill contributions. Furthermore, the project has treated more than 400,000 tonnes of domestic waste since its inception, indicating a significant diversion from landfills. With a designed capacity to process 400 tonnes of waste per day and the potential to reach a maximum of 500 tonnes, the plant can accommodate up to 77 per cent of the city's daily waste collection, which amounts to around 650 tonnes in Can Tho. The Can Tho WtE project plays a significant role in promoting sustainability. Its innovative waste management techniques and stringent waste acceptance policy redefine waste as a resource rather than a liability, aligning with sustainability principles.

Energy Generation

The WtE initiative is a sustainable and localised energy solution that uses municipal solid waste to generate electricity and heat. This novel strategy satisfies the demand for diverse energy sources while encouraging environmental management and renewable energy concepts. The initiative converts waste materials into valuable resources through incineration or anaerobic digestion. Incineration involves the combustion of waste at high temperatures, converting it into ash, flue gas, and heat. Anaerobic digestion, on the other hand, is a biological process that breaks down organic materials in the absence of oxygen, producing biogas and a nutrient-rich digestate. The electricity generated can be linked to the local power grid. Thermal energy can be used in district heating systems, industrial processes, and home heating, making it a greener alternative to fossil fuels.

Waste Reduction

The WtE effort seeks to alleviate the growing solid waste problem by transforming it into a profitable energy resource. This process reduces waste volume and repositions waste as a reservoir of potential energy. Innovative techniques like incineration and controlled anaerobic digestion channel latent energy within waste materials, mitigating environmental footprints and extending landfill life. This method contributes to a more efficient and lasting waste management paradigm.

Weaknesses

Waste Composition Variability

The conversion of municipal solid waste (MSW) into electricity is critical for environmental sustainability and energy resource diversification. Nevertheless, the diversity in waste composition, encompassing organic materials, plastic, paper, and metal, significantly influences the efficiency of WtE systems. In Can Tho, the predominant components of solid waste consist of biodegradable organic substances like vegetables, leftovers, and leaves, constituting 75 to 80 per cent of the wet weight. Plastic rubber comprises 13.6 per cent, with other wastes amounting to 6 per cent. Metal wastes represent the smallest proportion at 0.6 per cent.

The Can Tho WtE project has tackled this issue by implementing a stringent waste acceptance policy. It stipulates that only domestic waste meeting specific criteria is accepted, excluding types unsuitable for incineration. They include sludge, pathogens, animal carcasses, construction waste, demolition waste, medical waste, contaminated waste, industrial waste, and hazardous waste or other materials inappropriate for burning. By adhering to this policy, the project ensures that the waste processed aligns with the technology utilised in the WtE plant, thereby mitigating the risk of inefficient or ineffective waste treatment. This adaptive approach is crucial for the long-term success of WTE initiatives.

Health and Environmental Concerns

The Can Tho WtE project has faced concerns regarding its potential environmental and health impacts. Vietnam lacks established standards or regulations for properly handling and disposing of WtE residues, such as fly ash and bottom ash. As a result, controls for bottom ash are based on QCVN 07:2009/BTNMT, a national technical regulation concerning hazardous waste thresholds, particularly regarding the potential reuse of bottom ash in construction, as demonstrated at the Can Tho plant. Surprisingly, fly ash, containing hazardous substances that require appropriate treatment and disposal, was observed to be stored within the plant premises. Approximately 15 to 18 tonnes of fly ash, stabilised with a chelating agent and packed in waterproof bags, accumulated daily, awaiting regulatory guidance on safe treatment methods. Furthermore, the Can Tho local government (not investors) was found to be in charge of fly ash treatment. In 2019, the storage capacity neared its limit, leading to the Can Tho government relocating approximately 3,000 tonnes of fly ash by depositing it in an open site designated as a future landfill near the plant, potentially impacting the local community adversely.

High Initial Investment

WtE facilities provide answers for waste management and energy production but need considerable upfront investments. WtE projects can be expensive to build and operate,

making them less financially viable than other waste management solutions. The Can Tho WtE project has a total investment of approximately USD 47 million, which may limit its long-term sustainability. It comprises the acquisition and installation of modern technologies, the integration of different technologies, and the maintenance of infrastructure. Beyond the initial capital outlay, financial problems include continuous operational costs, maintenance charges, and environmental compliance. A comprehensive financial approach is required to address these projects' long-term sustainability and profitability.

For example, the project may charge localities for waste treatment, which can help cover the facility's operational costs. However, the current fixed price of 10.05 cents per kilowatt-hour is not attractive to investors. The proposed pricing mechanism under which the ministry will set price frames for electricity to be generated from biomass, waste, and solid waste could impact the revenue from waste treatment fees, and the project may sell by-products, such as biochar or fertilisers, produced during the waste treatment process. It can provide additional revenue streams and help offset the facility's operational costs.

Opportunities

Circular Economy

The Can Tho WtE plant has implemented circular economy practices in its operations, as evidenced by the Zero Waste to Mekong River: Pilot Circular Economy Model for Floating Markets in Can Tho project. It aims to promote waste reduction and circular economy principles in the local community by raising awareness about waste classification and collection, creating positive changes in people's behaviour, reducing water pollution, and improving the living environment. The project contains various activities, such as surveys, waste classification and reduction courses, and household waste treatment. It also encourages people to collect, sort, reuse, and recycle solid waste to extend product life and limit negative environmental impacts. The project has successfully implemented efficient, environmentally friendly models that save the cost of transporting rubbish and turning waste into a valued resource.

Energy Generation

The Can Tho WtE plant has a daily household waste processing capacity of 400 tonnes and generates about 150,000 kilowatt-hours of electricity daily. This electricity can cater to people's daily activities in the locality, contributing to the circular economy by producing energy from waste. The plant is expected to help Can Tho deal with household waste, as it consumes up to 77 per cent of the city's total waste volume. The electricity generated can be used to power homes, businesses, and public facilities in the city, reducing the reliance on fossil fuels and contributing to a more sustainable energy mix.

Revenue Streams

Beyond sustainable waste management and clean energy generation, WtE initiatives seek to improve economic viability. The Can Tho WtE project generates revenue through the sale of electricity to the national grid and the production of by-products that the city can utilise. The current fixed price of 10.05 cents per kilowatt-hour is not attractive to investors, but it is enough for some to inject money into the

field. If the Ministry of Industry and Trade (MOIT) proposes a pricing mechanism that allows electricity buyers and sellers to negotiate actual prices and provisions in power purchase agreements (PPA), this could attract more investors to WtE projects. Waste-to-energy facilities' knowledge and skills can be used to provide advisory services, positioning the project as an industry leader. Obtaining carbon credits or engaging in emissions trading markets can also provide cash.

Threats

Public Perception

WtE schemes often face significant social opposition, typically due to health or environmental concerns. Can Tho can learn from other successful WtE projects that have faced similar challenges. For instance, the WtE plant in Copenhagen, Denmark, initially met public opposition due to concerns about its environmental impact. However, the plant's operators successfully addressed these concerns through effective communication, community engagement, and stringent safety and environmental measures. Addressing these concerns necessitates open and transparent communication, involving people of the community in decision-making processes, and cultivating a feeling of shared responsibility. This community engagement is not just a strategy, but a fundamental aspect of the project's success, making stakeholders feel valued and integral to the project's success.

Establishing two-way communication lines and collaborating with local leaders and environmental advocates is crucial for the Can Tho project. However, showcasing the positive outcomes of WtE projects, such as decreased landfill dependency and clean energy generation, is equally important. This helps reframe the narrative and gain community support. Implementing sophisticated environmental monitoring programmes can provide real-time air quality and pollutant data, assuring environmental compliance. It is critical to constantly analyse and change communication techniques based on community sentiment in order to convert opposition into educated support.

Economic Downturn

Economic downturns can impact WtE projects' funding and financial stability. To mitigate these implications, a systematic approach comprising robust risk management procedures, strategic diversification of financing sources, and good communication with stakeholders is required. This approach involves financial model stress testing, scenario planning, and contingency planning. Diversifying financing sources, leveraging public-private partnerships, and emphasising long-term benefits such as job development and environmental sustainability can all help to preserve stakeholder trust and support during economic volatility.

Technological Risks

WtE initiatives face technological obstacles that necessitate rigorous risk management and continual innovation. The project's reliance on advanced WtE technology may pose maintenance, operational support, and potential obsolescence challenges, affecting efficiency and performance over time. Rapid technological advancements can make older technologies obsolete, making the project less competitive. Additionally, outdated or inefficient equipment can hinder performance, increasing maintenance costs and reducing overall competitiveness. Identifying potential hazards and preparing for them is critical for resilience. Technical breakthroughs risk obsolescence, making continual

research and collaboration with technology providers critical. It is also vital to foster a culture of collaboration and knowledge-sharing within the project team, as well as to engage with experts in waste management, energy conversion, and information technology, and to build comprehensive training programmes for workers. Strategic alliances with technology suppliers and industry leaders improve the project's ability to identify and handle issues before they arise.

Summary

The Can Tho WtE project holds significant promise in reducing landfill waste and promoting environmental stewardship. The project employs innovative processes like incineration and anaerobic digestion to generate electricity and heat, effectively reducing household waste on a daily basis. Despite the challenges of waste composition variability, health and environmental concerns, and high initial investment, the project offers opportunities for holistic waste management through circular economy practices. Revenue streams from electricity sales and by-product utilisation can enhance economic viability. The project can realise its full potential in fostering environmental sustainability and energy resilience by addressing public perception and navigating economic uncertainties with effective communication, community engagement, and transparent monitoring.

Table 7: SWOT Analysis Matrix of Can Tho Waste-to-Energy

SWOT Analysis Matrix: Can Tho Waste-to-Energy				
	Strengths	Weaknesses	Opportunities	Threats
SWOT Assessing Aspects	**Environmental Sustainability:** Waste-to-Energy projects transform municipal solid waste into valuable energy, reducing landfill waste and greenhouse gas emissions, and addressing climate change.	**Waste Composition Variability:** Waste-to-Energy (WtE) plants rely on the quality and composition of waste to generate energy. If the waste composition changes significantly, the plant's performance may be affected, leading to lower energy recovery or increased emissions.	**Circular Economy:** The Can Tho waste-to-energy plant has implemented circular economy practices by promoting waste reduction, recycling, and energy generation from waste, which helps to protect the environment and support sustainable development in the region.	**Public Perception:** Waste-to-energy plants may face public opposition due to concerns about the environmental impact and the potential for disincentivizing recycling or other more sustainable waste management solutions.
	Energy Generation: The Waste-to-Energy initiative uses municipal solid waste to generate electricity and heat, promoting environmental stewardship and renewable energy concepts, thereby reducing dependence on fossil fuels.	**Health and Environmental Concerns:** The Can Tho Waste-to-Energy Project in Vietnam faces environmental and health concerns due to lack of regulations for waste-to-energy residues, including fly ash. The local government is responsible for fly ash treatment, potentially impacting the community.	**Energy Generation:** The plant generates about 150,000 kWh of electricity per day, which can be used to serve the daily life of people in the locality.	**Economic Downturn:** The revenue from electricity generation is just additional income for investors, which may not be sufficient to cover the costs of waste treatment and electricity generation.
	Waste Reduction: The Waste-to-Energy initiative aims to transform solid waste into a profitable energy resource through innovative techniques like incineration and controlled anaerobic digestion.	**High Initial Investment:** The plant has a total investment of 1,050 billion VND (47 million USD), which is a significant investment for a waste-to-energy plant.	**Revenue Streams:** The Can Tho Waste-to-Energy Project generates revenue through electricity sales and by-product production. The current fixed price of 10.05 cents per kWh may attract investors, with potential for real pricing and advisory services.	**Technological Risks:** Waste-to-energy initiatives face technological challenges, necessitating risk management and innovation. Rapid advancements can make older technologies obsolete, affecting efficiency
Conclusion	The Can Tho Waste-to-Energy Project, utilising innovative processes, aims to reduce landfill waste and promote environmental stewardship, despite challenges like waste composition variability and high initial investment.			

The Policies or Regulations

Vietnam's Can Tho WtE project must comply with environmental regulations to ensure sustainable and responsible waste management. Some key regulations include Municipal Solid Waste (Management and Handling) Rules. These rules issued by the Ministry of Environment and Forests under the 1986 Environment (Protection) Act outline specific responsibilities for waste generators, provide detailed criteria for setting up solid waste processing and treatment facilities, and emphasise WtE conversion technologies. National technical regulations set standards for solid waste incinerators, hazardous thresholds of sewage sludge, limits of heavy metal in soil, surface water quality, groundwater quality, domestic wastewater, industrial emissions to dust and inorganic substances, wastewater of waste treatment area, noise, vibration, water quality for irrigation, and industrial wastewater.

Impact on Gender Equality and Social Inclusion

The Can Tho WtE project aims to improve waste management and generate clean energy in Can Tho. The project has created jobs, with 52 per cent of the workforce coming from the local community, with women making up 52 per cent of the employees. The gendered impact of climate change in the waste sector is influenced by the gendered division of household tasks and consumption patterns, which can affect women's roles in waste management and disposal. The project's Environmental and Social Monitoring Report (ESMR) highlights the need to ensure that women and other vulnerable groups are not disproportionately affected by waste management practices, including waste-to-energy projects.

It can be achieved through policies and practices that promote gender equality and inclusivity, such as providing equal opportunities for women in waste management jobs, ensuring that women's perspectives and priorities are taken into account in decision-making, and addressing the gendered division of household tasks and consumption patterns that influence waste generation and management in the household. The ESMR also emphasises the importance of mainstreaming gender equality and inclusivity in waste sector policies to address plastic pollution in Vietnam, which is relevant to waste management and the waste-to-energy project. Improved waste management can help ease women's overall work burden and contribute to a healthy and clean environment, which can decrease their care responsibilities for people sickened by pollution.

Funding Sources

Loan Agreements

Can Tho has four solid waste disposal facilities spread across its suburban Co Do and Thoi Lai districts, as well as the urban districts of O Mon and Thot Not. Approximately 70 per cent of the municipality's daily domestic waste is incinerated using cutting-edge international-standard technology provided by China Everbright Group. In December 2020, municipal authorities in Can Tho issued an investment certificate to China Everbright International Company to construct a USD 47 million WtE facility. Can Tho EB Environmental Energy Co. Ltd, a subsidiary of the investor, is in charge of the plant's operation.

The city's Department of Natural Resource and Environment reported that 98 per cent of urban residential waste was being systematically collected, with 75 per cent of homes actively participating in waste classification. The department's Deputy Director reaffirmed their commitment to the continuous partnership in waste collection, transportation, and treatment with Can Tho EB Environmental Energy and the districts.

The Can Tho WtE project was funded by various sources, such as the Asian Development Bank (ADB) and the China Everbright Group. The ADB granted a loan of USD 100 million from ADB to China Everbright International Limited to facilitate the construction of household WtE projects in multiple cities in Vietnam, including the Can Tho WtE project. The China Everbright Group, a leading company in the field of waste treatment, invested in the project and operates the plant through a subsidiary, Can Tho EB Environmental Energy Co. Ltd.

The funding process by the ADB for the Can Tho WtE plant involved multiple steps and agreements. In collaboration with China Everbright International Limited (CEIL), Can Tho likely developed a proposal outlining the project. This proposal would have included project goals, waste processing capacity, environmental impact assessment, and financial projections. Can Tho or CEIL, or both, would have submitted a formal application to the ADB for funding. The ADB would then conduct due diligence, which could involve evaluating the project's technical and financial feasibility, environmental and social impact, and CEIL's track record.

In October 2019, CEIL signed a memorandum of understanding (MoU) with the ADB, agreeing that the Can Tho WtE plant would meet emission limits based on the European Union Industrial Emissions Directive (EU IED). That same year, the ADB signed a USD 100 million loan facility agreement with CEIL to support its development, marking it the first ADB-funded WtE plant in Vietnam.

The ADB required CEIL to submit an ESMR detailing the plant's environmental and social performance, including compliance with emission limits and international standards. Additionally, CEIL had to provide an Annual Environmental and Social Performance Report (AESPR) to the ADB, which covered the plant's environmental and social performance, notable events, pollution control measures, occupational health and safety, social safeguards, and community engagement.

The project supported three of ADB's strategic priorities: environment and climate change, infrastructure development, and private sector development and operations. It also aligned with ADB's country partnership strategy for Vietnam, emphasising inclusive and environmentally sustainable growth. The ADB's involvement extends beyond financial support, offering technical assistance to ensure the WtE project aligns with international standards.

The collaboration between CEIL and ADB is a comprehensive partnership that combines financial support, technical expertise, and stringent environmental and social standards. This multifaceted approach ensures the successful and responsible implementation of the Can Tho WtE project, instilling confidence in its potential impact.

2.2.3 Water and Sanitation

Problem Overview

Currently, Can Tho has become one of the most important hubs for the economy, culture, and science in the Mekong Delta area. The Vietnamese Mekong Delta, a vital agricultural region, faces significant challenges, such as water scarcity and saline intrusion. The region currently faces limited access to safe drinking water, with shallow domestic groundwater wells often contaminated with arsenic and other metals[1].

To address these issues, strict limitations have recently been imposed on groundwater extraction. Water quality is a significant issue, particularly for essential domestic uses like drinking, cooking, and sanitation. Notably, a study undertaken by academics from the United Nations University found no apparent improvement in water quality since 2007 (Sebesvari, Z., & Renaud, F., 2017). According to government survey statistics, the primary sources of water for daily home usage in the delta, excluding drinking and cooking, are rivers, lakes, and ponds (36 per cent), wells (34 per cent), and piped systems (21 per cent). However, rainwater (23 per cent), wells (26 per cent), and rivers, lakes, and ponds (25 per cent), as reported by the General Statistics Office of Vietnam in 2008, are the primary sources for drinking and cooking. These findings underscore the need for comprehensive water quality control and rainwater harvesting as a crucial component of the region's water supply solution.

Solution

Rainwater Harvesting

Rainwater harvesting has been recognised as a solution for domestic water supply in Can Tho. The city's sustainability of freshwater resources, water, and wastewater services is under pressure, and rainwater harvesting has been identified as a preferred local water source. The project demonstrated that while rainwater can provide a good water source during parts of the year, its supply reliability during drier times would be limited. Rainwater harvesting is being implemented through underground rainwater harvesting tanks. The Tametotto tanks are 15 metres long and 10 metres wide and can store 100 cubic metres of rainwater, which will be treated for daily use and production. It also highlighted the fragmented water supply system in the city, indicating that a "one size fits all" solution may not be adequate to address all the water supply issues.

The delta region is home to a growing population, and its agricultural output is essential to national food security. Changes in rainfall patterns, increasing sea levels, and growing demand for water supplies, on the other hand, have strained the environment and jeopardised livelihoods. However, rainwater harvesting offers optimism. It is a proven strategy for collecting, storing, and managing rainwater for various purposes. Rainwater harvesting has gained popularity in the Mekong Delta due to its alleviation of water-related problems. This technique provides a long-term solution for protecting freshwater resources in the region while reducing dependency on ground and surface water sources.

Rainwater emerges as the primary water supply during the rainy season for different activities. However, it was selectively reserved during the dry season for essential purposes, mainly drinking and cooking. Rainwater harvesting systems are typically strategically built to absorb rainwater from residential rooftops, providing an efficient collecting procedure. Individuals experiencing depletion of their rainfall supply have taken up various means, such as buying water from neighbours, extracting it from neighbouring canals and rivers, and relying on bottled or well water as a backup option. Users frequently believed rainwater had significant advantages over other water sources, particularly in terms of odour, colour, taste, safety, and dependability, especially during the rainy season, providing a safe and reliable source of water.

Figure 4: Rainwater Harvesting Systems in a Household in a Peri-Urban Area

Source: Planning for sustainable urban water systems in adapting to a changing climate – a case study in Can Tho City, Vietnam, Synthesis Report, CSIRO, 2021

Project Assessment

Strengths

Abundant Rainfall

The Mekong Delta's abundant annual rainfall presents a significant opportunity for sustainable water management. By utilising rainwater harvesting, it can improve water security and lessen reliance on outside sources. Rainwater collection helps preserve current water reserves and ecosystems and meet local requirements. This strategy reduces climate variability and lays the foundation for a resilient and sustainable water future. It also complies with sustainability principles and environmental protection.

Preferred Local Water Source

Stakeholders in Can Tho have acknowledged the significance of rainwater harvesting as a preferred local water source. Rainwater harvesting involves collecting and storing rainwater from surfaces such as rooftops, which are used for various purposes. It

underscores the capacity of rainwater harvesting to meet the city's water supply requirements. Initiatives have been undertaken to install rainwater harvesting systems to assess rainwater quality and test economical methods to enhance it, particularly from rooftop sources. Pilot rainwater harvesting systems have been implemented at household levels and within a university building. The introduction of rainwater tanks emerges as a feasible adaptation strategy to bolster water supply in Vietnam, particularly given the pressing concerns surrounding pollution, drought, and salinity intrusion that considerably impact local water resources.

Environmental Sustainability

It helps lessen the strain on traditional reservoirs and acknowledges rain as an important resource. Communities can lessen their reliance on traditional water sources and prevent over-extraction and depletion by collecting and utilising rainwater. Rainwater collection aligns with a community-centric paradigm by reducing the need for energy-intensive distribution networks and treatment processes. Rainwater harvesting provides an additional source of water supply and acts as a resilience measure against the uncertainties associated with climate change. Rainwater harvesting can change how people see water consumption in society, encouraging mindfulness and environmental responsibility.

Weaknesses

Water Quality Concerns

Water quality is essential when it comes to water and sanitation initiatives, particularly rainwater collection. The water quality from rainwater harvesting projects in Can Tho can be affected by various factors, including air pollution, animal and bird droppings, insects, and dirt. The Mekong River produces 35 million cubic meters of silt annually, which can impact the quality of rainwater collected from rooftops and other surfaces. Also, the city has six geological-hydrologic levels containing water, with some levels having poor water quality. Proper maintenance and regular cleaning are crucial to ensure that the water quality from rainwater harvesting systems in Can Tho is safe for consumption. Additionally, regular monitoring and testing of the water quality should be conducted to identify and address potential contaminants promptly.

Dependency on Rainfall Patterns

The interplay between climatic variables and the reliability of rainfall influences the effectiveness of rainwater harvesting. The increasing unpredictability of the climate makes past rainfall patterns unreliable. A proactive and adaptive approach is needed, including robust infrastructure and calibrated storage capacities. In Can Tho, both have been implemented to address water management challenges, with notable success stories such as the Green Infrastructure Development. This initiative has seen the city developing a master green infrastructure plan for core urban districts, focussing on increasing rainwater harvesting and storage capacities in public spaces. Climate-resilient strategies should also involve community engagement and education about climate variability and adaptive water management practices. Despite the challenges, climate variability can provide opportunities for innovation and diversification, such as integrating complementary water sources.

Technical Knowledge

One of the main problems with rainwater harvesting systems in rural areas is the lack of professional skills. This mismatch hampers these efforts' viability and sustainability. Targeted capacity-building initiatives, such as specially designed educational programmes for local communities to create, implement, and sustain efficient systems, are required to close this knowledge gap. To guarantee practical applicability, this involves receiving hands-on training.

Opportunities

Capacity Building

Education and training programmes are crucial for enhancing local capacity in rainwater harvesting systems. Collaborative projects like SUMERNET (Sustainable Mekong Research Network) have facilitated capacity building and knowledge sharing among local institutions and researchers, enhancing urban water system planning and management in Can Tho. By offering complete skill sets, they enable communities to navigate intricate systems effectively. These initiatives involve practical training for farmers and community leaders to discuss rainwater gathering concepts. This experiential learning method underscores the need for ongoing education and adaptability to shifting social demands and environmental shifts by fostering competence and confidence.

Sustainable Urban Water Management

Rainwater harvesting can significantly contribute to sustainable urban water management in Can Tho. By reducing the reliance on traditional water sources, it can improve the city's resilience to climate change impacts. Additionally, it can help manage the effects of urban growth and address issues such as flooding and groundwater management. The benefits of rainwater harvesting are manifold, including reducing strain on public water systems, conserving water resources, and serving as a potent adaptation measure against climate change-induced adversities such as salinity intrusion and water pollution in the Mekong Delta, where Can Tho is located.

Threats

Climate Change Impacts

The efficiency of rainwater collection largely depends on the stability and predictability of rainfall, both currently threatened by unpredictable climate change. Communities, farming methods, and water management tactics are all impacted by this uncertainty, which also affects the amount and consistency of water harvested. The uncertainty around climate change makes it more challenging to maintain rainwater harvesting projects over the long run. Can Tho address rainwater harvesting concerns through innovative strategies, including adopting resilient infrastructure and adaptive techniques. For instance, the city is experimenting with Japan's underground rainwater harvesting tanks, like Tametotto, to ensure a dependable water supply for daily and industrial activities. Additionally, Can Tho is proactively managing floods by constructing channels to segregate floodwaters, erecting dykes, and installing water gates to regulate river levels, particularly during the rainy season.

Competing Water Uses

Effective management of water resources is facing a massive problem due to the growing demand for water because of industrial and agricultural activities. During peak periods, the availability of rainwater, a crucial resource for sanitation, becomes limited. It increases rainwater supply demand, worsening waste management, hygiene, and public health. The regularity and sufficiency of water supplies are critical to the success of sanitation programmes. Innovative water management techniques, including integrating new sources and optimising current systems, are crucial to addressing the issue. Water resources can be lessened by using water-efficient technologies in business and agriculture. To find cooperative solutions that balance the needs of various sectors while guaranteeing water availability for vital sanitation practises, stakeholders – including governmental bodies, sectors, and water management authorities – must collaborate.

Infrastructure Vulnerability

Infrastructure for collecting rainwater is essential for preserving sustainability and resilience, particularly during extreme weather events. Floods and cyclones disrupt the balance between infrastructure and nature, posing threats to the reliability and longevity of these systems. Cyclones harm catchment surfaces, gutters, and storage tanks, and floods damage catchment regions, storage facilities, and essential components. This multifaceted impact disrupts immediate functionality and poses long-term challenges to system resilience. To ensure the durability and resilience of rainwater harvesting programmes, strategic planning and resilient design are crucial. The stress on routine maintenance and quality control measures should make stakeholders feel secure and confident in the sustainability of the systems. These measures, along with comprehensive training and capacity building, adaptive management practices, continuous monitoring and evaluation, fostering collaborative partnerships, engaging stakeholders actively, and investing in ongoing research and development efforts, are paramount to the sustainability of the systems.

Summary

Can Tho in the Mekong Delta is exploring using rainwater harvesting as a sustainable water management solution. The abundance of rainfall ensures water security and reduces reliance on external sources, preserving existing reserves and ecosystems. However, water quality concerns and dependency on rainfall patterns necessitate rigorous maintenance and monitoring protocols. Technical knowledge gaps and capacity-building programmes are vital for success. Despite these challenges, rainwater harvesting offers opportunities for resilience against climate change impacts, mitigating flood risks, and conserving water resources. The potential of rainwater harvesting to mitigate flood risks should reassure stakeholders and instil hope for a more resilient and sustainable water future.

Table 8: SWOT Analysis Matrix of Rainwater Harvesting in Can Tho

SWOT Analysis Matrix: Rainwater Harvesting				
	Strengths	Weaknesses	Opportunities	Threats
SWOT Assessing Aspects	**Abundant Rainfall:** Rainwater harvesting in Mekong Delta can enhance water security, reduce reliance on external sources, preserve water reserves, and comply with sustainability principles for a resilient future.	**Water Quality Concerns:** Rainwater can contain pollutants, such as heavy metals and other contaminants, which may require additional treatment to ensure safe drinking water.	**Capacity Building:** Education and training programs in rainwater harvesting systems, such as SUMERNET, enhance local capacity and knowledge sharing, promoting effective urban water system planning and management.	**Climate Change Impacts:** The efficiency of rainwater collection is largely dependent on the constancy and predictability of rainfall, both of which are currently threatened by unpredictable climate change.
	Preferred Local Water Source: Can Tho City stakeholders recognise rainwater harvesting as a sustainable water source, implementing pilot systems to improve quality and address pollution, drought, and salinity issues.	**Dependency of Rainfall Patterns:** The dependency of rainwater harvesting on rainfall patterns in Can Tho City is significant, as the availability of rainwater for collection and storage depends on the amount and frequency of rainfall.	**Sustainable Urban Water Management:** Rainwater harvesting in Can Tho City enhances sustainable urban water management, reduces reliance on traditional sources, and mitigates climate change impacts, addressing flooding and groundwater management issues.	**Competing Water Uses:** The growing demand for water from industrial and agricultural activities is causing limited rainwater availability, affecting sanitation, hygiene, and public health.
	Environmental Sustainability: Rainwater harvesting is a sustainable solution for water management in Can Tho City, as it relies on natural rainfall and reduces the reliance on traditional water sources. This can help mitigate the effects of climate change on water availability and contribute to the city's sustainable development strategy	**Technical Knowledge:** The limited technical knowledge of rainwater harvesting in Can Tho City is a concern, as it can hinder the adoption and implementation of this technology.		**Infrastructure Vulnerability:** Infrastructure for collecting rainwater is essential for preserving sustainability and resilience, particularly during extreme weather events. Floods and cyclones disrupt the balance between infrastructure and nature, posing threats to the reliability and longevity of these systems
Conclusion	The Mekong Delta's abundant rainfall and environmental sustainability make it a promising location for rainwater harvesting, but challenges like water quality and climate change necessitate a holistic approach.			

The Policies or Regulations

Rainwater harvesting has been considered an essential (domestic) water supply source. The Vietnamese Water Resources Law of 2012 has actively promoted the collection and utilisation of rainwater (as stated in Articles 4, 39, 41, and 54 of the VWRL 2012). However, there is limited guidance regarding specific directives concerning rainwater utilisation. For instance, the Ministry of Natural Resources and Environment (MONRE) support in Circular 32/2011/TT BTNMT primarily focuses on the quality of collected rainwater without addressing its intended use (MONRE 2011).

Impact on Gender Equality and Social Inclusion

The Vietnamese Water Resources Law of 2012 has actively promoted the collection and utilisation of rainwater (as stated in Articles 4, 39, 41, and 54 of the VWRL 2012). However, there is limited guidance regarding specific directives concerning rainwater utilisation. For instance, the Ministry of Natural Resources and Environment (MONRE) support in Circular 32/2011/TT BTNMT primarily focuses on the quality of collected rainwater without addressing its intended use (MONRE 2011).

However, it is crucial to implement these initiatives in a way that is sensitive to gender disparities and inclusive of all members of the community. This involves actively involving women and marginalised groups in planning, executing, and monitoring rainwater harvesting systems. Efforts should also address cultural and educational barriers that hinder women's participation in community initiatives and their understanding of climate change issues. It is important to be aware of these barriers and take responsibility for addressing them. In summary, the implementation of rainwater harvesting in Can Tho has positively impacted gender equality by extending clean water access to marginalised groups and promoting the adoption of environmentally sustainable infrastructure measures. It is essential to ensure that these initiatives are rolled out to prioritise gender responsiveness and inclusivity, actively involving women and other marginalised populations.

Funding Sources

Adaptation Fund

The initiative forms a component of the Can Tho City Water Supply Improvement Project, a collaborative endeavour involving the Socialist Republic of Vietnam, the Can Tho People's Committee, and multiple Japanese and Vietnamese entities such as the Japan International Cooperation Agency (JICA), Nippon Koei Co., Ltd., Swing Corporation, and Mitsubishi Corporation. Furthermore, the project is also funded by the Adaptation Fund, a worldwide fund dedicated to supporting projects and initiatives aiding countries in adapting to the impacts of climate change.

JICA prioritises projects that align with Vietnam's national development plans and focus areas. Rainwater harvesting conforms to goals related to climate change adaptation and sustainable water management. Typically, JICA collaborates with Vietnamese government agencies or public institutions. For this project, partnering with a relevant local entity such as the Can Tho City Department of Natural Resources and Environment or the Department of Water Supply would be advisable.

The project concept and planning phase begins with identifying the need for a rainwater harvesting project in Can Tho. It involves assessing the current water supply situation, understanding the local context, and determining the feasibility of implementing such a system. A preparatory study evaluates the project's technical, economic, and environmental viability. This study includes a detailed analysis of the project's costs, benefits, and potential risks and a preliminary environmental impact assessment (EIA) to identify any environmental concerns. Economic viability is assessed using indicators such as the economic internal rate of return (EIRR), a calculation performed by the highly skilled JICA Study Team based on the project's costs and benefits.

The project's potential environmental and social impacts are assessed and mitigated according to JICA's guidelines, ensuring no harm to the local environment or communities. Once its feasibility and viability are confirmed, a funding application is submitted to JICA. This application, which includes a detailed project proposal, budget, and implementation timeline, underscores the project's alignment with JICA's goals. JICA reviews the proposal and funding application, considering the project's potential community impact, and environmental and social sustainability. If approved, JICA provides funding and technical assistance for implementation, including construction, operation of the rainwater harvesting system, and training and capacity building for local stakeholders.

2.3 North Minahasa, Indonesia

North Minahasa Regency, with its administrative hub and capital in Airmadidi, is located in the province of North Sulawesi. This region, strategically located between Manado and the port city of Bitung, is not only a growing population center, with an estimated 229,368 residents by 2022, but also a potential powerhouse for renewable energy. The Regency encompasses various subdistricts, including Airmadidi, Dimembe, Kalawat, Kauditan, Kema, West Likupang, East Likupang, and Wori, all part of the larger Minahasa Regency. The President of the Republic of Indonesia has formally recognised North Minahasa as a Special Economic Zone (SEZ). Within this region, Likupang, a subdistrict in North Minahasa, has been designated as one of Indonesia's five Super Priority Destinations (DSPs), a high honour bestowed by the Indonesian Ministry of Tourism.

2.3.1 Renewable Energy and Energy Efficiency

Problem Overview

As energy demand surges in densely populated regions of Indonesia, there is a growing concern that the nation's energy trajectory may exacerbate global greenhouse gas emissions. Recognising the magnitude of the impending challenge, Indonesia set an aggressive goal in 2015 to reduce greenhouse gas emissions by 29 per cent (using its own resources) and 41 per cent (with international assistance) by 2030. Furthermore, the government has taken decisive steps to promote the use of renewable energy sources, demonstrating its commitment to reducing emissions at the household level. The need for a rapid transition to environmentally friendly, renewable energy sources has never been more pressing, especially given the possibility that global energy demand will surpass the global population growth rate.

At the same time, Indonesia is rich in renewable energy sources such as geothermal, solar, wind, and biomass. Indonesia has a consistent and sufficient supply of sunlight all year, making it an area with tremendous solar energy potential, particularly for photovoltaic (PV) energy. However, the use of solar energy for power generation remains relatively low, and the nation's renewable energy capability has yet to be fully utilised. This is primarily due to the country's continued reliance on coal-fired power facilities, which dominate its electricity consumption landscape.

Solution

The Likupang Solar Power Plant

The Likupang Solar Power Plant is a symbol of the bold decision made by the Indonesian government and private investors to capitalise on North Minahasa's abundant solar resources. This reflects the country's determination to reduce greenhouse gas emissions and embrace sustainable energy alternatives. The plant, which spans a 29-hectare area in Wineru Village, East Likupang District, is equipped with 64,620 solar panels arranged strategically and maintained by 120 array boxes, 24 inverter sets, and six PV boxes. Since its launch in September 2019, Vena Energy has been capturing solar energy resources, significantly boosting the area's electricity production capacity. With a maximum potential

of 21 megawatts and an average daily operating duration of up to 12 hours, the plant starts operating at 05:30 WITA. Its solar thermal power absorption capacity can reach up to 15 megawatts under optimal conditions. The plant plays a crucial role in Indonesia's energy transition, demonstrating the feasibility and benefits of large-scale solar power generation.

The energy absorption capability is limited to 3 megawatts in unfavourable weather circumstances, such as heavy rain in the Likupang area. One noteworthy aspect of the plant is its dedication to environmental protection. The plant's switch to solar energy lowers the carbon footprint associated with conventional energy sources by reducing its annual carbon dioxide emissions by 25,000 tonnes. This move towards clean energy supports national initiatives to lessen the harmful effects of greenhouse gas emissions and the global fight against climate change. Additionally, the plant improves grid-wide and regional energy security. Given the increasing difficulties in Indonesia's energy security environment, the continuous production of solar panels guarantees a dependable electricity supply, decreasing reliance on fossil fuels and boosting energy resilience.

The Photovoltaic Power Generation System, or PLTS, is a prime example of an eco-friendly energy facility because it has no moving parts, produces few noises, and emits no dangerous exhaust pollutants that could harm the surrounding area. Situated on arid agricultural land, the plant has proven to have a positive environmental impact through its generation of clean electricity and proactive implementation of steps to prevent potential adverse effects. The plant has implemented sedimentation and surface water management strategies to ensure environmental sustainability. Strict monitoring ensured local regulations were followed after thorough environmental and social effect assessments. The regulatory environmental approval process in Indonesia, known as AMDAL (Analisis Mengenai Dampak Lingkungan Hidup), was applied to the project. The local government demonstrates its commitment to environmental responsibility and sustainable energy practices by ensuring the project complies with these requirements following applicable environmental regulations.

The city and local government actively engage in the plant through various initiatives and collaborations. Notably, the project secured environmental regulatory approval from the North Minahasa Regency government, receiving an Environmental Permit (number 06/ILK/DPM-PTSP/II/2017) on February 22, 2017. The electricity produced by the plant is sold to PT PLN (Persero) under a 20-year power purchase agreement, indicating a firm commitment from the government-owned utility. During construction, the project employed up to 900 local workers, boosting the local economy and creating jobs. The plant's workforce comprises 80 per cent locals, ensuring the project's benefits are shared with the community. The plant's focus on environmental preservation is evident through its significant reduction in carbon emissions using solar energy, thus lowering the carbon footprint compared to traditional energy sources. Additionally, the plant is integrated into the regional tourism strategy, promoting the area as one of Indonesia's five super-priority destinations.

The city government of Likupang gains several benefits from the plant. Firstly, the plant provides the local community with a stable and reliable electricity supply, essential for economic development and daily life. This consistent power reserve supports the quality of life for residents and fosters economic growth. During construction, the project employed local workers, boosting the local economy and creating job opportunities. It directly benefits the workers and stimulates the local economy by keeping income within the community.

Additionally, the use of solar energy by the plant significantly reduces carbon emissions, addressing a primary environmental concern. Reducing the city's carbon footprint contributes to a cleaner environment, improving residents' overall quality of life. The plant's operation generates revenue for the government through the sale of electricity to PT PLN (Persero) under a power purchase agreement. This revenue can be reinvested into local projects and initiatives, further supporting the city's development and infrastructure.

Furthermore, the presence of the plant has led to community engagement and development initiatives, such as the creation of the Likupang Special Economic Zone. This zone promotes sustainable development and economic growth while preserving the local environment, providing additional benefits to the city and its residents.

Figure 5: Likupang Solar Power Plant
Source: Cabinet Secretariat of the Republic of Indonesia, 2020

Project Assessment

Strengths

Renewable Energy Sources

Utilising sunlight as a renewable energy source, the Likupang Photovoltaic Power Plant is a trailblazing example of a sustainable energy infrastructure. This plant offers a clean power source and lessens dependency on fossil resources. The operational philosophy of Likupang acknowledges the sustainability of sunlight and aligns with international initiatives to combat climate change. The plant symbolises a change towards a greener, more resilient, and ecologically sensitive energy landscape for present and future generations.

Large Capacity

The plant has a total capacity of 21 megawatts, making it one of Indonesia's largest solar power plants. This capacity allows the plant to generate significant amounts of clean energy, contributing to the country's renewable energy sector and reducing dependence on fossil fuels. The plant can produce 33,400 megawatt-hours of renewable energy annually, enough to power up to 20,138 Indonesian households

and reduce approximately 28,071 tonnes of greenhouse gas emissions. The large capacity of the plant is a testament to Indonesia's commitment to increasing the share of energy supplied from renewable energy sources, as outlined in the plans of the Ministry of Energy and Mineral Resources to increase the capacity of grid power generation through new and renewable energy.

Carbon Emissions Reduction

The plant has offset 25,000 tonnes of carbon dioxide emissions per year, reducing greenhouse gas emissions. This reduction in carbon emissions is significant as it helps mitigate the negative impacts of climate change and supports Indonesia's efforts to reduce its carbon footprint. The plant's commitment to environmental preservation is one of its most significant advantages, as it drastically cuts carbon emissions by using solar energy, reducing the carbon footprint associated with traditional energy sources.

Weaknesses

Intermittency

The Likupang Solar Power Plant, like other solar power plants, faces the challenge of intermittency due to its dependence on sunlight. The plant is a sustainable and forward-thinking energy provider that acknowledges the intermittent nature of solar power generation. The plant maximises energy output during peak sunlight hours and plans to optimise operational efficiency through advanced forecasting systems and energy storage solutions. This approach ensures a reliable power supply despite the intermittent nature of sunlight. Solar power generation depends on sunlight availability, making it cyclical and less reliable than fossil fuel-based power generation, especially during cloudy days or at night.

High Initial Costs

The plant's high initial cost shows the significant capital investment required for construction and development. This includes land acquisition, solar panel installation, inverters, transmission lines, and other necessary infrastructure. Despite the financial challenges, this investment is a strategic commitment to a cleaner, more sustainable energy future. The high initial investment costs associated with the plant refer to the significant capital required to construct and set up the solar power facility. Expenses include purchasing and installing solar panels, inverters, batteries, and other necessary equipment, as well as the cost of land acquisition, permits, and other project development expenses.

Likupang's approach involves a calculated and visionary investment in the future, positioning the plant as a key player in the transition to sustainable energy, reducing environmental impact and fostering energy independence in the long run. The plant secured USD 40 million in private-sector financing from the Asian Development Bank, part of a USD 160 million portfolio financing for renewable energy assets. Support from Leading Asia's Private Infrastructure Funds (LEAP) and Climate Fund for the Private Sector in Asia II (CFPS II) helped bridge the financing gap and mitigate first-mover risks. By addressing these financial challenges, Likupang establishes itself as a responsible custodian of environmental resources and a model of financial prudence and innovation in the renewable energy sector.

Land Requirements

The plant faces significant land requirements for large-scale photovoltaic installations. Spatial constraints, particularly in densely populated areas, could limit its ability to promote clean energy. In response to this challenge, Likupang employs inventive strategies to optimise space utilisation efficiency, including strategic site selection, use of vertical solar panels, and implementation of solar panels on existing structures. This decision stems from findings in the Environmental and Social Impact Assessment report for the Likupang Solar Power Plant, indicating that land for the project was obtained in June 2017. The project was implemented on 29.4 hectares of agricultural land procured from a single landowner, streamlining the acquisition process. The choice of location was influenced by factors such as proximity to electricity sources and simplified land procurement procedures.

Furthermore, the project involves collaboration with local communities and integrating solar technology into existing infrastructure. This holistic approach respects the delicate balance between environmental impact and landscapes, establishing Likupang as a leader in sustainable energy and an accountable steward of land resources. By addressing these issues, Likupang contributes to a cleaner, more sustainable future in areas with limited space.

Opportunities

Technological Advancements

The Likupang Solar Power Plant presents several opportunities for technological advancement as the plant utilises advanced solar technology, including high-efficiency solar panels and inverters. They can improve the overall performance and efficiency of the solar power generation process, and the plant is directly connected to the national electricity network, which allows for the integration of smart-grid technologies that can improve the efficiency and reliability of the power grid. Although the plant does not currently have battery storage, integrating battery storage systems in the future could help stabilise the grid and ensure a more consistent supply of electricity, particularly during periods of low sunlight or high demand.

Government Incentives

In sustainable energy, Likupang demonstrates a remarkable balance between economic feasibility and environmental responsibility. It accelerates its impact on a local and global scale by utilising government subsidies, incentives, and advantageous laws. The plant benefits from various incentives related to income tax, import duties, fiscal measures, and non-fiscal support. These incentives encompass a range of benefits the Indonesian government provides to renewable energy projects.

Income tax facilities entail a 30 per cent deduction of net income for six years, accelerated depreciation and amortisation of assets, and a 10 per cent dividend withholding tax concession. Import duty exemptions are available for specific activities like geothermal development. Fiscal incentives extend beyond tax relief to include support for land and property taxes, geothermal development, and financing via government-assigned state-owned enterprises. They are complemented by non-fiscal incentives, offering further support in areas such as tax relief, geothermal development, and financing through state-owned enterprises. These incentives support regional and

national renewable energy goals while bolstering Likupang's economy. The district's capacity to take advantage of these opportunities and its dedication to clean and sustainable energy practises are demonstrated by its strategic acumen and adaptability in traversing the ever-changing energy landscape, instilling confidence in the project's management.

Economic Development

The plant has provided clean and reliable electricity to approximately 15,000 local households, supporting the development of the region's socioeconomic zone. This has been achieved by directly connecting the plant's electricity production system to the national electricity network, enhancing efficiency and enabling the seamless integration of renewable energy into the national grid. Providing clean and reliable electricity has contributed to the region's economic development, catering to businesses and industries that require a stable power supply.

Threats

Limited Expansion Challenges

The plant faces several threats due to the readiness of the State Electricity Company (PLN) to accept new power plants. Vena Energy, the plant's developer, has to follow the General Plan for Electric Power Supply (RUPTL), which may limit the plant's expansion opportunities. The plant's success depends on the readiness of PLN to accept new power plants, which could threaten the project's future growth.

Waste Management

The lack of recycling schemes for solar panels in Indonesia could lead to a significant accumulation of solar panel waste, posing an environmental challenge. Although the Indonesian government has emphasised the need to achieve net zero emissions, they have yet to develop a sustainable recycling plan for used solar cells. Energy experts have warned that without proper recycling measures, the world may face a substantial amount of solar panel waste by 2050, which could contribute to a global environmental disaster. Therefore, the absence of recycling schemes for solar panels in Indonesia presents a significant environmental threat, including the potential for increased waste accumulation and its associated impact. However, the implementation of recycling schemes could not only mitigate these environmental risks but also create new economic opportunities, such as the development of a local recycling industry and the generation of new jobs.

Competition from Other Energy Sources

The plant faces competition from other energy sources, particularly fossil fuels, which are often cheaper and more readily available in the short term. Fossil fuels are generally cheaper to produce and maintain than solar energy. This cost difference can make them more attractive to consumers in the short term, especially for industries that require large amounts of energy. Fossil fuels are widely available and have been the primary energy source for many years. Their established infrastructure, including refineries, pipelines, distribution networks, and supply chain, from extraction to delivery, makes them more accessible and easier to integrate into existing energy systems.

In the short term, industries and households may prioritise the reliability and consistency of fossil fuels over the long-term benefits of solar energy. It can lead to a preference for fossil fuels when energy demand is high or when immediate needs require a quick energy solution. In summary, the competition from other energy sources, particularly fossil fuels, is a significant challenge for the plant. While solar energy offers long-term benefits and a sustainable future, fossil fuels' short-term costs and availability can make them more attractive to consumers and industries.

Summary

The Likupang Solar Power Plant in Indonesia, with a capacity of 21 megawatts, is a significant renewable energy facility contributing to sustainable development. It generates clean energy, electrifying over 20,000 households annually and reducing carbon dioxide emissions. Despite its strengths, it faces intermittency, high initial costs, limited expansion opportunities, and a lack of recycling schemes. Despite these challenges, Likupang's role in Indonesia's energy transition is significant, and technological advancements and government incentives bolster its long-term sustainability.

Table 9: SWOT Analysis Matrix of the Likupang Solar Power Plant

SWOT Analysis Matrix: The Likupang Solar Power Plant				
	Strengths	Weaknesses	Opportunities	Threats
SWOT Assessing Aspects	**Renewable Energy Sources:** The plant uses solar energy, which is a renewable and sustainable source of electricity, reducing dependence on fossil fuels and contributing to the reduction of greenhouse gas emissions	**Intermittency:** The plant's electricity production is dependent on weather conditions, such as sunlight and rainfall. If the weather is not favorable, the plant's electricity production can decrease, which may lead to lower revenue and a higher reliance on traditional energy sources	**Technological Advancement:** The plant utilizes advanced solar technology and is connected to the national electricity network, enhancing efficiency and reliability through smart grid technologies.	**Limited Expansion Challenges:** The success of the Likupang Solar Power Plant depends on the readiness of the state electricity company (PLN) to accept new power plants, as Vena Energy, the plant's developer, has to follow the General Plan for Electric Power Supply (RUPTL).
	Large Capacity: With a total capacity of 21 megawatts, the Likupang Solar Power Plant is one of the largest solar power plants in Indonesia, capable of generating significant amounts of clean energy	**High Initial Costs:** The Likupang Solar Power Plant has a high initial cost due to the significant capital investment required for the construction and development of the project. This includes the cost of land acquisition, solar panel installation, inverters, transmission lines, and other necessary infrastructure	**Government Incentives:** The Likupang Solar Power Plant has several opportunities for government incentives, such as tax incentives, exemption from import duties, fiscal incentives, and non-fiscal incentives.	**Energy Storage Challenges:** The plant does not have battery storage, which could be a disadvantage in times of low sunlight or high demand for electricity.
	Carbon Emissions Reduction: The plant has offset 25,000 tonnes of carbon dioxide emissions per year, contributing to the reduction of greenhouse gas emissions.	**Land Requirement:** The plant faces spatial constraints, particularly in densely populated areas, which could limit its ability to promote clean energy.	**Economic Development:** The plant has provided clean and reliable electricity to approximately 15,000 local households, supporting the development of the region's social-economic zone.	**Waste Management:** Indonesia's lack of recycling schemes for solar panels poses a significant environmental threat, potentially leading to increased waste accumulation and potential global disaster by 2050.
Conclusion	The Likupang Solar Power Plant, despite challenges like intermittent generation and startup costs, is a key player in the global transition towards clean energy through sustainable energy infrastructure.			

The Policies or Regulation

As mandated by the Indonesian Constitution, the government plays a pivotal role in managing all natural resources, including renewable energy. Its primary objective is to enhance the well-being of its citizens. This involves overseeing the renewable energy sector, formulating policies and regulations, and issuing licenses to entities seeking entry into Indonesia's renewable energy market. The key legislation governing energy matters is Law 30/2007 on Energy, amended by Law 6/2023 on the Establishment of Government Regulation in Lieu of Law 2/2022 concerning Job Creation, commonly known as the Job Creation Law. The New and Renewable Energy Bill (NRE Bill), which the Indonesian Parliament has been deliberating for the past three years, will provide the overarching framework for renewable energy.

Indonesia has demonstrated its commitment to global climate change agreements by endorsing the three primary ones, including the United Nations Framework Convention on Climate Change, its Kyoto Protocol, and the Paris Agreement. In the realm of renewable energy initiatives, Indonesia made a significant move in 2022 by participating in a G20 gathering where it signed a memorandum of understanding (MoU) with 14 global institutions and philanthropic organisations. This MoU, aimed at expediting the nation's energy transition, is facilitated through the Indonesia Energy Transition Mechanism Country Platform, commonly known as the ETM Platform.

Regional and local administrations play a crucial role in bolstering the renewable energy sector within their respective areas. Each regional government is responsible for devising a provincial energy plan to execute the National Energy Plan (RUEN). The RUEN, the central government's comprehensive national energy management strategy, is designed to implement the National Energy Policy (KEN) from 2014 to 2050, regulated by GR 79/2014 and PR 22/2017.

With the implementation of PR 11/2023, regional governments overseeing provincial affairs have been granted increased authority in managing and supervising renewable energy endeavours. Their jurisdiction encompasses the management of biomass and/or biogas utilisation as fuel at the provincial level, along with overseeing various renewable energy sources such as solar, wind, hydroelectric, and ocean thermal energy.

Local administrations hold significant sway in expediting renewable energy projects within their jurisdiction. In the waste-to-energy sector, local governments act as the governing body with the prerogative to determine tipping fees for waste management, thereby influencing the pace and direction of renewable energy projects.

Impact on Gender Equality and Social Inclusion

The project reached most of its outlined goals regarding measurable objectives related to its design and monitoring framework. These encompassed targets such as annual electricity production, reducing greenhouse gas emissions, fostering job creation, local procurement, and advancing women's economic empowerment. The project also incorporated certain elements to address gender disparities. The Asian Development Bank has provided funding for the project's development, opening job

prospects for women in the maintenance, operation, and construction sectors. This effort included five key indicators in the design and monitoring framework to assess gender performance. These indicators were developed to promote gender equality, with a special emphasis on women's economic empowerment. Efforts were focused on creating job possibilities for women, which included solar technical training, technical help to women entrepreneur organisations, and the implementation of a women's empowerment initiative.

Overall, the project achieved four gender-related targets and made significant progress towards the remaining one. It demonstrates a dedicated approach to achieving these targets, which involves implementing additional activities to complement the primary objectives. They included (i) meeting the targeted job creation during operational phases, (ii) ensuring at least 30 jobs for women out of a total of 800 jobs during the construction phase, (iii) providing the planned annual capacity-building training on renewable energy and entrepreneurial skills, explicitly targeting women entrepreneurs, (iv) offering technical support to at least five training participants to help them start small businesses, and (v) reporting a partially met target concerning the number of women trained as solar farm operators and technicians employed within the service sector.

Funding Source

Build-Own-Operate-Transfer (BOOT)

The Likupang PLTS was built after the Power Purchase Agreement (PPA) was signed at the end of 2017 and took approximately 1.5 years to complete at a total investment cost of USD 29.2 million. 64,620 solar panels are precisely organised on a total of 29 hectares. The Asian Development Bank (ADB) has also played a key role in the Likupang solar power plant project. ADB approved a 20-year loan of USD 12.49 million from its ordinary capital resources for developing and constructing a 21-megawatt solar power plant in Likupang as part of the Eastern Indonesia Renewable Energy Project. Since September 5, 2019, Vena Energy has begun using these sun-catching devices as a new source of electrical energy. Under the Build-Own-Operate-Transfer (BOOT) scheme, the electricity sales and purchase contract lasts 20 years. This agreement represents a long-term commitment in which the responsible entity builds, owns, operates, and eventually transfers the power generation facility to the government. The BOOT model is well-known for its capacity to deliver a stable and reliable source of electricity over an extended length of time, so it encourages sustainable energy practices and maintains a continuous supply throughout the contractual duration.

In the case of the Likupang Photovoltaic Power Plant (PLTS), the supervising organisation is typically a private developer or a utility corporation. Vena Energy, a prominent private Independent Power Producer (IPP) specialising in the plant design, building, and commissioning of solar and wind power projects, plays this crucial role in the Likupang PLTS. Their involvement extends throughout the project development process, from initial design to final implementation. A solar energy endeavour such as the Likupang PLTS requires substantial investment in equipment and infrastructure. It includes purchasing solar panels, inverters, and

associated components, as well as acquiring necessary governmental licences and permits. These preliminary steps lay the groundwork for the successful functioning of the power plant. Vena Energy will acquire ownership of the Likupang PLTS once it is operational. They have entire authority over the facility's daily operation, maintenance, and management for the duration of the 20-year contract. This ownership structure empowers Vena Energy to generate revenue by selling the electricity Likupang PLTS produces. The entity operates the plant with unwavering efficiency, ensuring it constantly satisfies the predetermined power generation requirements. It includes routine equipment maintenance, timely repairs, and constant performance monitoring. These efforts increase the plant's efficiency and overall power production while protecting the return on investment.

The 20-year contract term is a significant component of the project's lifespan, which is defined by the BOOT scheme. After the contract expires, ownership of the Likupang PLTS typically reverts to the government or the designated project recipient, as specified in the contract. This transfer comprises the assets, infrastructure, and operational experience gained throughout the BOOT period, ensuring a smooth transition of responsibilities. The BOOT concept significantly benefits private enterprises such as Vena Energy and the energy sector in general. Firstly, it allows private enterprises to participate actively in creating and operating energy projects, minimising the financial burden placed on governments or utilities. Second, because the private company is vested in the power plant's performance and lifespan, it develops an environment conducive to effective operation and maintenance. This commitment, in turn, boosts the growth of renewable energy sources like the Likupang PLTS, contributing to long-term energy security and power generation sustainability.

In conclusion, the Likupang Photovoltaic Power Plant, under Vena Energy's stewardship, exemplifies the BOOT scheme's successful implementation in the renewable energy field. This comprehensive approach ensures the efficient generation of solar power. It exemplifies a collaborative model that can drive the development of sustainable energy solutions, underlining the significance of public-private partnerships in addressing global energy needs.

Source Photo by Tan Dao
www.pexels.com/photo/a-busy-street-with-street-vendors-in-a-city-14167600

Source Photo by Sơ Minh: www.pexels.com/photo/a-street-in-a-city-17406185

3.0 Lessons Learned, Possible Improvements, and Concerns

3.1 Lessons Learned

3.1.1 Adaptability

The flexibility of programme initiatives is essential to their success in changing contexts. Energy efficiency and adoption can be increased by offering incentives to electric vehicles, such as discounted parking rates. Rainwater harvesting on school roofs can save water costs and increase public knowledge of climate change adaptation. The initiative intends to improve access to essential services, economic growth, job creation, and connectivity in the Mekong Delta region. Rainwater harvesting is a versatile technique that may be applied in various contexts, as evidenced by its implementation in urban settings in rural Vietnam. The Likupang Solar Power Plant is the largest ground-mounted solar project in Indonesia. It has successfully reduced greenhouse gas emissions and provided clean, renewable energy to the region.

3.1.2 Co-Benefits

These programmes seek to lower greenhouse gas emissions and promote sustainability. Parking rebates and incentives encourage the use of electric vehicles, improving air quality and energy security. The smart grid helps reduce greenhouse gas emissions and other pollutants by facilitating the connection of large amounts of renewable energy. Clean energy generation, such as the Can Tho Waste-to-Energy and the Likupang Solar Power Plant, reduces dependency on fossil fuels and carbon dioxide emissions. It helps to achieve the overarching objective of lowering greenhouse gas emissions.

3.1.3 Cost-Savings

Beyond initial investments, these programmes can result in significant cost reductions and economic benefits to the city government. For example, financial incentives such as parking fee reductions can be used to support electric vehicles. By optimising energy use, the smart-grid project lowers energy costs. Waste-to-Energy initiatives turn waste into electricity. By reducing the need for water and piped water, rainwater harvesting improves water resilience. The Likupang Solar Power Plant investment helped reduce Indonesia's dependence on fossil fuels and promote renewable energy development. These programmes support sustainability and financial efficiency.

3.1.4 Collaboration

Collaborative efforts involving local governments, stakeholders, and international organisations such as the Global Environment Fund (GEF) and the United Nations Industrial Development Organisation (UNIDO) have collaborated with Hang Tuah Jaya Municipal Council (MPHTJ) on various projects to promote low-carbon initiatives such as incentives for electric vehicles (EVs) in the city. The collaboration aims to integrate climate change considerations into urban planning strategies and strengthen the National Urban Policy Framework, which will promote using low-carbon transport options such as incentives for EVs.

Additionally, collaborations between the Hang Tuah Jaya Local Council and the Green Growth Asia Foundation (GGAF) in rainwater harvesting in Hang Tuah Jaya's school aim to create an enabling environment for mainstreaming sustainable water management in schools, reduce water bills, educate students on climate change, raise public awareness on rainwater harvesting, and share water harvesting experience of the schools with other organisations Similarly, the Can Tho Waste-to-Energy project, a joint effort involving the Asian Development Bank (ADB), China Everbright International (CEIL), and the Japan International Cooperation Agency (JICA), aims to enhance solid waste management, mitigate methane emissions, and boost renewable energy production in Vietnam's Mekong Delta through the construction and operation of waste-to-energy plants.

3.1.5 Community Participation

In order to promote engagement and empowerment, programme activities require active community participation. A strategy encouraging electric vehicles in Hang Tuah Jaya and environmentally friendly transportation methods serves as an example of this, improving the sustainability and resilience of the city's transportation infrastructure. Community feedback is used to shape efforts that promote sustainable transportation behaviours. In order to promote shared responsibility for waste reduction, community engagement is also essential to improving sustainable waste management techniques. In order to develop practical solutions for sustainable water management, community involvement is essential, particularly in rainwater harvesting projects.

Lastly, community involvement is emphasised in a project on sustainable energy practices to support the city's energy infrastructure. Community engagement is important because it ensures that the economic benefits generated by these projects are shared locally, fostering economic growth, job creation, and improved living standards. This approach also helps to gain social acceptance, minimise conflicts, and build long-term partnerships that contribute to the success and longevity of the initiatives.

3.2 Possible Improvements

The previously discussed processes undoubtedly provide benefits that inevitably enhance the public's general welfare. However, it's important to note that there is always room for improvement to reach their maximum potential. This potential for improvement should be seen as a source of hope and optimism for the future. The potential improvements for every practice covered in previous sections of this study are described in depth in the following subsections, offering a roadmap for further progress and development.

3.2.1 Incentives and Parking Rebates for EVs

The Malaysian Hang Tuah Jaya Municipal Council (MPHTJ) has introduced an incentive programme that lowers parking costs for electric vehicles in the city by 50 per cent. This incentive was introduced in 2018 and aims to promote the use of EVs and reduce carbon emissions. To encourage more people to transition to electric vehicles, one potential improvement for Hang Tuah Jaya's incentive and parking rebate for EVs programme could be to increase the number of charging stations available in the city. The city should also consider providing additional incentives, like tax exemptions or refunds, to promote the use of electric vehicles.

3.2.2 Smart-Grid Project: Smart-Metre

The smart-grid project in Hang Tuah Jaya has made significant progress in promoting renewable energy and energy efficiency programmes. However, prospects for enhancement could increase the project's influence. First, a more prominent geographic region inside Hang Tuah Jaya might be included in the continuing smart-metre effort, which is now in its pilot phase. It would extend the benefits to a larger population of companies and residents.

Furthermore, Hang Tuah Jaya may promote the widespread use of renewable energy sources like solar and wind turbines to support sustainability initiatives further. The city may successfully lessen its reliance on fossil fuels and reduce carbon emissions by encouraging the adoption of these technologies. This comprehensive strategy improves the smart-grid project's environmental impact and fits with the larger objectives of encouraging community resilience and sustainability. By implementing these improvements, Hang Tuah Jaya can further enhance its smart-grid project and create a more sustainable, energy-efficient, innovative urban environment.

3.2.3 Rainwater Harvesting in Schools

The rainwater harvesting project in schools in Hang Tuah Jaya, Malaysia, seeks to reduce water bills, educate students on climate change adaptation, raise public awareness, and share experiences with other organisations. The actions listed below can be put into action to further enhance this endeavour, including organising workshops, seminars, or open days at the schools to involve the community in the project and to showcase the advantages and methods of rainwater harvesting. It could promote greater adoption of the technique, disseminate knowledge, guarantee the long-term efficacy of the rainwater harvesting systems in schools, and create a maintenance schedule. It may entail educating school staff or students to perform regular checks and maintenance tasks.

3.2.4 The Can Tho Clean Air Action Plan

The Can Tho Clean Air Action Plan, formulated through collaboration with Clean Air Asia and the Vietnam Environment Administration, aims to improve air quality and support Can Tho's strategic development goals. The plan could incorporate targeted campaigns and educational programmes, partnerships with local schools, community centres, and social media platforms, and clear guidelines for enforcing regulations to improve its effectiveness. It should also align with other urban development initiatives, such as transportation and energy plans, to ensure air quality considerations are integrated into the broader urban planning strategy. Reviewing and updating the plan to reflect changing circumstances, new technologies, and emerging challenges is crucial to ensure its relevance and effectiveness in addressing Can Tho's air quality issues.

3.2.5 Can Tho Waste-to-Energy Project

The Can Tho Waste-to-Energy Project, supported by the Asian Development Bank (ADB), is a crucial step in treating 400 tonnes of domestic waste per day and improving the city's overall environment. To further boost the project, a few enhancements could be considered. By encouraging waste reduction, reusing, and recycling actions, the project might strive to reduce waste creation. It can enhance the project's overall sustainability and lessen the waste that needs to be treated. The project might optimise energy efficiency by fully harnessing the energy production process and cutting down on energy use. It could lower greenhouse gas emissions and increase the project's overall sustainability.

3.2.6 Rainwater Harvesting in Vietnam's Mekong Delta

There are a few important factors to consider when improving rainwater harvesting systems in the Mekong Delta. Rainwater harvesting is a common practice in rural regions. Thus, raising knowledge of it and encouraging its adoption throughout the Mekong Delta is critical. This can be achieved by enacting focused educational initiatives and raising public awareness through campaigns highlighting rainwater collection's many advantages. It is imperative to guarantee the quality of collected rainwater, especially for drinking. First-flush and treatment procedures that raise water quality and safety criteria must be used. Government subsidies designed especially for rainwater harvesting systems can motivate households, increasing the systems' affordability and encouraging a wider uptake.

To ensure a broader reach and effectiveness, it is essential to extend rainwater harvesting initiatives to villages and districts strategically. Implementing larger-scale rainwater collection technologies is crucial to cater to the water requirements of entire towns. Integrating these technologies into the city's overall water management system is indispensable. By guaranteeing sustainability and offering a dependable water supply infrastructure to more significant populations, this technique enhances the overall resilience of communities in the area.

3.2.7 Likupang Solar Power Plant

With the current 15-megawatt solar project proving successful, there is ample room for capacity growth to boost clean energy production even more and add to the region's power supply. Moreover, the potential of the Likupang Solar Power Plant to

inspire other renewable energy projects is substantial. Additionally, implementing battery storage systems could help store excess energy generated during peak sunlight hours and release it during periods of low sunlight or high demand, ensuring a more stable and reliable power supply while allowing extra energy storage. The project's long-term viability may also be enhanced by investigating cutting-edge solar technologies and procedures, which might further enhance the plant's efficiency and performance. By considering these possible improvements, the Likupang Solar Power Plant may maintain its position as an integral generator of renewable energy in the area and serve as an example of Indonesia's sustainable energy development.

3.3 Potential Concerns

A few aspects of the previously mentioned practices could cause local governments to rethink putting the measures under discussion into action. These variables include community involvement, financing issues, and the possible effects of political transitions.

Hang Tuah Jaya, Malaysia, supports low-carbon transportation and green technology efforts to combat climate change. However, in addition to technological and infrastructural problems, implementing a smart-grid scheme in the city presents difficulties, such as deploying smart-grid systems that may pose technical challenges related to system integration, scalability, and reliability. Additionally, educating the public about the benefits of smart grids and addressing any concerns or misconceptions they may have will be important for the successful implementation of the system. Environmental and socioeconomic effects of the Central Mekong Delta Region Connectivity Project include habitat destruction, water pollution, and erosion. Concerns about social and cultural acceptability surround rainwater harvesting in the Mekong Delta, and the financial viability of these systems is influenced by things like initial investment, upkeep expenses, and substitute water supplies. Land area issues with the Likupang Solar Power Plant could affect the utilisation of agricultural land. The city should incorporate peaking power plants to stabilise the energy supply and reduce supply fluctuations caused by intermittent solar power output. Appropriate community engagement and collaboration are crucial to solving these issues.

A key barrier to executing the above-mentioned practices – like the Central Mekong Delta Region Connectivity Project's financial viability – is obtaining sufficient funds. The sensible allocation of resources and the prompt distribution of funding are essential to the project's success. Ensuring the project's financial sustainability is fundamental to facilitating its income generation or cost savings for the local economy, ultimately contributing to its long-term success. The Can Tho Waste-to-Energy project's financial viability depends on prompt cash disbursement and effective resource utilisation. Maintaining the project's financial stability will be essential to its capacity to provide income or reduce expenses for the community's economy, which will significantly enhance its long-term success.

Community involvement is consequential in addressing issues and ensuring the successful implementation of initiatives, such as smart-grid projects. It involves continuous communication and active participation, enabling developers to work collaboratively to resolve issues. Community involvement is vital for smart-grid initiatives, where clear

communication channels and accessible educational resources are essential. This is because smart-grid systems involve complex technologies and require the cooperation of various stakeholders, including government agencies, energy providers, technology companies, and the public.

Effective communication and education can address concerns and misconceptions about smart grids, promote understanding of their benefits, and ensure that all stakeholders know their roles and responsibilities in the implementation process. Community involvement encourages sustainable behaviours, addresses potential issues, and optimises advantages in solar energy incentives, waste-to-energy programmes, and rainwater harvesting systems. Nonetheless, there are complications in the broad adoption of sustainable practices. To fully realise the promise of these initiatives and address governmental changes, regulatory hurdles, and public acceptance, local communities must be actively involved and supportive.

The change in political transition could threaten programme sustainability. Strong policies and regulations are essential for the planning and implementation of smart-grid initiatives, as well as efficient collaboration between many stakeholders, including government agencies, utilities, and technology companies. Similarly, challenges to the growth of solar energy projects in Indonesia include high manufacturing costs, legal requirements, and the need for supportive policies. Political transitions could trigger changes to the rules and policies that govern these initiatives, affecting how well-established rules are followed and whether new ones are introduced. Furthermore, it may impact finance options and availability, which could affect the project's timeliness and financial sustainability.

4.0 Financing Options

Local governments, as the driving force behind programmes that promote resilience and sustainability in their communities, are at the forefront of the battle against climate change. Their pivotal role is underscored by the emergence of various innovative climate financing options, which empower them to execute effective grassroots climate change programmes. This section delves into these innovative funding options, demonstrating how local governments in Malaysia, Vietnam, and Indonesia can spearhead environmental objectives and resilient communities.

4.1 Existing Financing Options

Various financing options are available in Malaysia, Vietnam, and Indonesia based on the information obtained from the sources mentioned. Financial options, such as equity, debt instruments, guarantees, and insurance, are crucial for financing climate change initiatives. Debt instruments raise money for climate-related projects, whereas equity mechanisms secure funds for environmentally conscious projects. Insurance and guarantees offer a safety net and reduce risk, ensuring project completion even if the borrower encounters difficulties. Insurance plans provide monetary defence against climate-related hazards like floods and severe weather. These instruments contribute to a resilient and sustainable future by demonstrating a commitment to sustainable practices and establishing a strong financial infrastructure to address the problems posed by climate change. These options include:

4.1.1 Malaysia

Like many nations, Malaysia faces the urgent challenge of mitigating and adapting to climate change. Since local governments are key players in promoting sustainable development, innovative approaches to climate finance are required. A developing country, in particular, needs an innovative financial approach to leverage and attract private finance to promote sustainable development. Public finance alone is insufficient to meet the resource requirements for sustainable development and climate change mitigation and adaptation. Innovative financing mechanisms can help mobilise additional resources and provide new sources of funding that would not have been available through traditional financing channels. These mechanisms can also promote private sector participation in sustainable development initiatives, leading to more efficient and reliable solutions.

The Hang Tuah Jaya Municipal Council acknowledges the gravity of reducing carbon emissions and combatting air pollution, thus allocating a portion of its budget to incentivise the adoption of electric vehicles within its jurisdiction through measures such as financial rebates. Furthermore, the Global Environment Facility (GEF) and the United Nations Industrial Development Organization (UNIDO) play vital roles in advancing smart-grid systems in Hang Tuah Jaya, with GEF likely providing funding and assistance for their development. These systems offer potential benefits such as enhanced energy efficiency, reduced greenhouse gas emissions, and increased sustainability of Hang Tuah Jaya's energy infrastructure. UNIDO's involvement includes supporting smart grid implementation, promoting renewable energy utilisation, and fostering partnerships to address energy poverty, security, and climate change.

The Hang Tuah Jaya Local Council and the Green Growth Asia Foundation (GGAF) have collaborated on a Rainwater Harvesting Project as part of Hang Tuah Jaya's Climate Action Plan 2030, aiming to reduce greenhouse gas emissions and mitigate climate change impacts. In Malaysia, several climate financing options are available to support initiatives to mitigate and adapt to climate change. These options encompass a range of mechanisms, from international funds to domestic incentives and financing programs. Here are some key climate financing options in Malaysia:

Equity Instruments

Green Sukuk

In line with Malaysia's adherence to Islamic finance, the introduction of Green Sukuk offers an innovative avenue for financing climate initiatives. Defined explicitly as a green Islamic bond, Green Sukuk is a revolutionary mechanism to finance efforts against climate change. It can potentially mobilise significant resources from the USD 2 trillion Islamic finance industry towards financing sustainable and environmentally friendly investment initiatives. This strategic cooperation aims to leverage Islamic finance's distinctive characteristics to accelerate funding for environmental sustainability projects and support Malaysia's broader climate objectives, instilling a sense of optimism about the potential impact of Islamic finance on climate initiatives.

Malaysia has a significant USD 34.7 billion debt market, making it a major participant in Islamic financing. The Socially Responsible Sukuk (SRI) Guidelines, which Malaysia introduced in 2014, are a framework that aims to connect financial instruments that comply with sharia principles that are both environmentally sustainable and socially responsible. This strategy incorporates social and environmental impact into the financial ecosystem while strongly emphasising adherence to Islamic finance rules.

Public-Private Partnership

Public-Private Partnership (PPP) was initially presented to Malaysians with the introduction of the Malaysia Incorporated Policy in the 1980s, which aimed to promote collaboration between the public and private sectors. Malaysia's government has aggressively encouraged and supported PPP agreements, realising their critical role in driving economic progress. PPP projects have benefitted several industries, including infrastructure, healthcare, and transportation. Malaysia has adopted some PPP models across various industries to accomplish sustainable development. The following are a few well-known PPP categories in Malaysia:

· Build-Operate-Transfer (BOT)

BOT (Build-Operate-Transfer) is a popular PPP model in Malaysia, particularly in infrastructure projects. It involves the private sector designing, financing, and constructing the project, operating it for a specified period, and then transferring it back to the government. This model was adopted in the late twentieth century to address increasing infrastructure demands while leveraging private sector efficiency and capital. By reducing the demand for public resources, BOT projects alleviate the burden on public resources, allowing the government to focus on other critical areas. The private sector frequently employs user fees or other revenue-generating techniques to recover its investment. For the benefit of both public and private parties, the regulatory framework for the BOT project is established, providing assurance and clarity. It increases project viability and investor confidence.

· Build-Lease-Transfer (BLT)

In Malaysia, the funding mechanism known as the BLT model involves the private sector financing, designing, and building infrastructure projects. The model originated in Malaysia's pursuit of innovative financing mechanisms for critical infrastructure projects. The private sector can actively relieve the government's budget by actively participating in the project's design, financing, and construction. Post-construction, the private sector leases the completed facility to the government for a predetermined period, paying lease fees to the private entity. The government pays the private company leasing payments in exchange for using the infrastructure to offer public services. After the lease, the government regains control of the infrastructure, guaranteeing its continuous operation and long-term viability. In Malaysia, a well-established regulatory framework for BLT projects encourages private-sector involvement.

· Build-Own-Operate (BOO)

BOO initiatives in Malaysia have been adopted due to the nation's economic policies in the pursuit of private sector participation in infrastructure projects without burdening public finances. Private entities finance, design, and construct infrastructure projects, often through alliances or corporations. The concession period allows revenue generation through user fees or service charges. Malaysia's strong regulatory structure, which includes the Private Finance Initiative Act of 2012, guarantees transparency in the country's risk-sharing, dispute resolution, and procurement procedures. BOO projects are evidence of Malaysia's dedication to creative finance and cooperative development. They are dynamic tools that promote collaboration between the public and private sectors as the country continues to manage the challenges of modernisation and urbanisation.

· Private Finance Initiative (PFI)

In Malaysia, the Private Finance Initiative (PFI) has completely changed how public services are provided and infrastructure is developed. The government implemented it as part of the Ninth Malaysia Plan. It allowed the public sector to create and manage the public infrastructure while utilising the innovations and efficiency of the private sector. PFI transfers the capital investment cost to the private sector by including private organisations in financing, planning, and executing public projects. The risk-sharing approach is set up so contractual agreements guarantee a fair distribution. PFI projects provide accountability and long-term sustainability by encompassing the entire project lifespan, from inception to maintenance. The PFI Act of 2012 is the primary legislative tool in establishing the PFI regulatory framework. PFI project implementation is supervised by regulatory agencies, such as the Unit Kerjasama Awam Swasta (UKAS), to guarantee compliance and openness, providing reassurance and confidence in the system.

Debt Instruments

Malaysian Government Securities (MGS)

The Malaysian government issues Malaysian Government Securities (MGS), which are fixed-rate, long-term bonds with coupon payments. These securities play a crucial role in raising funds for development projects. They are the most actively traded bonds in Malaysia and are traded in a competitive auction conducted by Bank Negara Malaysia (BNM). The BNM frequently issues benchmark securities such as three-, five-, seven-, and ten-year MGS to create a benchmark yield curve. To further extend the yield curve, 15- and 20-year MGS have also been issued. Semi-annual coupon payments are made, and principal repayment occurs at maturity. MGS are offered in both traditional and Islamic versions.

Government Investment Issues (GII)

The Malaysian government issues Government Investment Issues (GII), which are long-term, non-interest-bearing government securities based on Islamic principles, to finance development expenses. On behalf of the government, BNM holds competitive auctions to issue GII. The issuance size varies from RM1 billion to RM4.5 billion, contingent on the requirements for funding. Both conventional and Islamic versions of GII are offered. The Islamic version is based on the idea of *murabahah*, which is a postponed markup sale of goods under sharia laws. The government will redeem the GII at maturity and give holders the nominal value of the securities. The auction calendar pre-announces the GII issue programme, with issuance sizes ranging from five-, seven-, and ten- to 15- or 20-year maturities.

Malaysian Treasury Bills (MTB)

The Malaysian government issues Malaysian Treasury Bills (MTBs), short-term discount securities, to raise short-term capital for working capital. MTBs are discounted through a competitive auction, with initial maturities of three months, six months, and one year. MTBs are available in conventional and Islamic versions, with a standard transaction lot size of RM5 million. Benchmark securities have a liquid secondary market, with daily average transaction volumes ranging from RM1 billion to RM2 billion. Bursa Malaysia is the trading platform for MTBs, a component of the Malaysian bond market. This market includes Islamic and conventional papers such as GII, Bank Negara Papers, Cagamas Papers, Private Debt Securities (PDS), and Asset-Backed Securities (ABS).

Private Debt Securities (PDS)

In Malaysia, a wide variety of short- and long-term debt instruments issued by private or quasi-government corporations are called Private Debt Securities (PDS). The PDS market was created to satisfy the funding requirements of privatised infrastructure projects, particularly the Malaysian economy's funding needs. Its goals were to supplement the more developed and established bond market and offer an alternative to bank borrowing. The PDS market offers a range of instruments, such as Islamic bonds, zero-coupon, floating-rate, and fixed-rate bonds. With outstanding issues rising from RM0.4 billion in 1987 to RM152 billion at the end of 2000, or 28 per cent of the GDP, the PDS market in Malaysia has seen substantial expansion. The PDS market is the most prominent relative to other regional economies, which indicates the government, Bank Negara Malaysia, and the Securities Commission's successful collaboration in growing the Malaysian bond market.

Guarantee and Insurance

Contract Guarantee or Bond Insurance

An insurance known as Contract Guarantee or Bond Insurance in Malaysia assures one party (the principal) that the insured will carry out their responsibilities, like making a payment or carrying out a contract. This guarantee is usually provided by a surety, which may be an insurance firm and takes the form of an insurance or bank guarantee. As a surety, the insurance company guarantees that the party will fulfil its responsibilities. In the event of non-performance, the principal will receive payment for the guarantee. The insurance company subsequently sues the person who neglected to uphold its end of the bargain to recover damages. In order to guarantee that contractors are carrying out their duties, this kind of insurance is frequently utilised in the construction sector.

The Contract Guarantee or Bond Insurance is a surety bond, a contract between the insurance company, the obligee (the client of the bondholder), and the principal (the bondholder). It is not a typical insurance policy. In contrast with conventional insurance policies, the surety bond is not recorded on the guaranteed party's balance sheet. In the event of non-performance, the surety attempts to retrieve the money from the principal. In order to assure contract fulfilment, performance bonds and bank guarantees are frequently provided in the Malaysian construction industry before the contract even begins. The demands for performance bonds might be interpreted differently. However, they are typically used to ensure the contractor's performance and can be invoked by the employer in the event of a specific contract breach.

4.1.2 Vietnam

Can Tho, situated in the heart of the Mekong Delta in Vietnam, faces significant environmental challenges due to climate change. Various climate funding initiatives have been implemented in Can Tho to address these issues, focusing on clean air, renewable energy, and water resource management. This section explores three prominent initiatives: the International Development Funding for the Clean Air Action Plan, the Can Tho Waste-to-Energy Project Loan Agreement, and the Adaptation Fund for Rainwater Harvesting.

Can Tho has actively addressed air pollution, exacerbated by urbanisation and industrialisation, with support from the Clean Air Fund through international development funding. The loan agreement for the Can Tho Waste-to-Energy project, signed in 2018 between China Everbright International Limited (CEEGL) and the Asian Development Bank (ADB), allocated a USD 100 million loan from ADB to CEEGL to construct household waste-to-energy projects across various Vietnamese cities. These projects incorporate advanced clean technologies to manage waste effectively.

Furthermore, the Adaptation Fund has undertaken a project in Vietnam integrating rainwater harvesting as an intervention to address water management challenges, particularly in the Mekong Delta region. As a global climate finance mechanism, the Adaptation Fund supports initiatives that aid vulnerable communities in developing nations to adapt to climate change. Climate funding initiatives facilitated through partnerships with international organisations, financial institutions, and development agencies are instrumental in bolstering Can Tho's resilience to climate change impacts. By putting in place innovative projects focusing on air quality, waste management, and water resource management, these initiatives enhance environmental sustainability and contribute to the overall well-being of Can Tho's residents amidst changing climatic conditions. Climate financing for local government programmes in Vietnam can take various forms, leveraging traditional and innovative approaches. These are some innovative climate financing options that local governments in Vietnam could consider.

Equity Instrument

Public-Private Partnership (PPP)

· Build-Own-Transfer (BOT)

Vietnam's rapid economic expansion and growing need for modern infrastructure have led to the adoption of the BOT model as a funding mechanism for infrastructure development. Under the model, an infrastructure project is designed, financed, built, operated, and maintained by a private entity for a predetermined time. The government approves projects based on their viability, economic benefit, and compatibility with national development objectives. Roles, responsibilities, and obligations are outlined in a negotiated concession agreement. The private company manages the infrastructure, produces the income and recovers expenses. The government regains ownership and operational responsibility after the concession period. The BOT model exemplifies how innovation and infrastructure development may be fuelled by cooperation between the public and private sectors.

· Build-Transfer-Operate (BTO)

This model, a crucial tool for the government, involves determining the requirements for important infrastructure, evaluating its viability, and getting clearance from the appropriate authorities. After obtaining funding and implementing up-to-date technology, the private company begins operations. Infrastructure assets are under government control, while commercial organisations oversee and maintain the infrastructure. Tariffs, user fees, and other revenue-sharing programmes are used to raise money to pay for operational expenses and provide returns. The BTO model is a flexible and dynamic framework that encourages public-private sector cooperation

to support Vietnam's infrastructure development. It continues to be essential to the country's dedication to progress, innovation, and resilience and is set to bring in a new era of superior infrastructure.

· Build-Own-Operate (BOO)

The Build-Own-Operate (BOO) model has been implemented in Vietnam to subsidise vital infrastructure projects. This method determines and evaluates the demands for infrastructure and has emerged as the go-to option for initiatives requiring long-term involvement of the private sector. The government sets the BOO arrangement's conditions, and the private company obtains funding via loans, equity, or a mix of the two. The private partner then takes over ownership of the facility, maintains and runs it, and generates revenue through tariffs, user fees, or other revenue-sharing arrangements to pay back the original investment and maintain operational costs.

· Concessions

Vietnam is leveraging concessions to bridge the infrastructural gap and develop a new development phase. For vital infrastructure projects, the government allocates specific rights to private entities. The process begins with identifying appropriate projects and assessing their economic feasibility, social impacts, and compatibility with national development plans. Concessions are awarded to qualified entities upon approval. These entities then commence the construction process and are responsible for the infrastructure's administration and maintenance. Revenue is generated through user fees, tolls, or other revenue-sharing schemes. Concessions continue to be a dynamic instrument for cooperation between Vietnam's public and private sectors despite challenges such as legislative complexity and renegotiation risks.

· Lease

Vietnam is adopting leasing as a financial strategy to satisfy the demands of modern infrastructure. The procedure includes locating appropriate properties for leasing to the private sector and assessing initiatives for their economic feasibility and compatibility with national development objectives. Private entities devise and secure a comprehensive lease agreement through direct investment or funding. The private lessee is responsible for using resources wisely and adhering to the lease terms. The government gains from having a consistent source of funding without having to handle direct operational duties. However, some challenges need to be resolved, like establishing reasonable lease terms, ensuring regulations are followed, and striking a balance between the requirements of the public and the private sectors. Leasing models provide a flexible way to satisfy changing national demands, draw private investment, and develop infrastructure.

· Joint Ventures

Joint ventures are a crucial part of the strategic approach to collaboration that drives Vietnam's economic success. Through collaborations, national and international organisations can combine resources, distribute risks, and harness complementary skills. Finding strategic initiatives that align with economic viability and national development goals is the first step in the process. The goals, terms, and conditions

of a cooperation are mentioned in the Joint Venture Agreement (JVA). Partners may provide loans, investments from other sources, or a combination of equity and assets. Joint ventures promote shared achievements and accountability while expediting project completion. However, challenges like cultural disparities and complicated regulations need to be resolved.

Debt Instruments

Green Bonds

In Vietnam, green bonds are essential for financing environmentally sustainable projects and addressing climate change impacts such as rising sea levels and agricultural shifts. These bonds, often labelled as "green" or "climate" bonds, allow investors to support initiatives contributing to a low-carbon, sustainable future. The green bond market in Vietnam is growing, and both governmental and private companies are involved. Governmental organisations, financial institutions, private businesses, and local governments work together to issue green bonds. The funds raised are used to support initiatives that have a demonstrable positive impact on the environment, like sustainable transport infrastructure, energy efficiency upgrades, and renewable energy projects. The funds raised may also support climate adoption initiatives like sustainable agricultural methods and water management systems.

Vietnam has been exploring using green bonds to finance climate change. As of October 2020, the nation had four green debt issues issued by government-guaranteed entities, totalling around USD 284 million. However, the absence of a legislative framework for green bonds in Vietnam has sparked worries about the possibility of greenwashing. Despite this, a survey carried out in 2021 in association with the Asian Development Bank (ADB) indicated that investor interest in green bonds is improving, and market knowledge is rising in Vietnam. Establishing a regulatory framework and a proactive approach from financial institutions are considered prerequisites for expanding the green bond industry in Vietnam. Therefore, even if Vietnam has a lot of potential for green bonds, more development in this field will require the creation of a regulatory framework and the proactive involvement of financial institutions.

Loans

· Multilateral Development Banks (MDBs)

The Vietnamese government has cooperated with Multilateral Development Banks (MDBs) to finance significant urban infrastructure projects, including the World Bank and the Asian Development Bank (ADB). These loans are essential for funding initiatives that support social impact, economic viability, and national development goals. MDBs offer technical help, favourable terms, and concessional financing. These loans are used in several urban infrastructure sectors, including energy, transportation, social infrastructure, water and sanitation, and urban planning. Additionally, they promote the Public-Private Partnerships (PPPs) that encourage innovation and efficiency in building urban infrastructure. Despite challenges such as delays in project execution and intricate regulations, the partnership has produced noteworthy accomplishments in urban infrastructure development.

Grants

· Government Infrastructure Grants

Vietnam's economic growth has led to a focus on urban infrastructure, with the government allocating grants to projects across transportation, utilities, housing, and public facilities. These grants are strategically allocated based on national development priorities, aiming to enhance connectivity, provide essential services, and create resilient urban spaces. The procedure entails determining the most important initiatives, assessing their fit with development objectives, and distributing funds. In addition, these incentives cover municipal and local needs, encouraging inclusive growth and resolving differences between urban and rural communities. Despite implementation delays and budget constraints, achievements are significant, with the future promising innovative funding models, increased private sector collaborations, and sustainable urban solutions.

· Multilateral Development Banks (IDBs) Grants

To address its developmental issues, Vietnam has teamed up with global financial organisations such as the World Bank and the Asian Development Bank (ADB). These subsidies, which address social welfare, environmental sustainability, infrastructure development, and poverty reduction, are essential to the country's development. The MDBs improve institutional capabilities and project management skills by offering technical expertise and capacity-building programmes. Notwithstanding challenges like complicated implementation and legal frameworks, the collaboration has produced benefits like enhanced social services and infrastructures. Vietnam is anticipated to concentrate on sustainability, innovative financial approaches, and technology to address new issues in its future cooperation with MDBs.

· Municipal Grants

Vietnam's rapid urbanisation has led to the development of municipal grants, which are financial support provided by local governments to guide urban development initiatives. These grants focus on infrastructure enhancement, public services, and community welfare. In order to guarantee that the project directly meets local needs, the process frequently involves community interaction. Grants are frequently used to assist cultural and social projects, encourage local economic growth, and upgrade municipal infrastructure. These funds are anticipated to be crucial in supporting smart city initiatives, environmental practices, and technologically advanced urban experiences as metropolitan areas develop. They support Vietnam's urban living's social fabric and its physical infrastructure.

Guarantee and Insurance

Surety Bonds

According to Decree 68/2014, non-life insurance companies in Vietnam may offer surety bonds, sometimes called "guarantee insurance", to secure their clients' contractual commitments in favour of a third party. This kind of insurance assures a third party that the insured will carry out their end of the bargain, which could include making a payment or fulfilling a contract. In the event of non-performance, the insurance company recovers the losses from the non-performing party and pays the guarantee to the principal. Particularly in the construction sector, surety bonds are frequently

utilised to guarantee that contractors perform following their contractual duties. Although banks in Vietnam have historically issued bonds and letters of guarantee, an insurance company may offer more security than a bank. Surety bonds are contracts between three parties: the obligee (the client of the bondholder), the surety (the insurance company), and the principal (the bondholder). Surety bonds are not like regular insurance policies. In the case of non-performance, the surety attempts to recover the money from the principal.

4.1.3 Indonesia

The BOOT (Build-Own-Operate-Transfer) scheme is a public-private partnership (PPP) model that allows private organisations to conduct large development projects under contract with public sector partners. The BOOT scheme is commonly used for infrastructure projects such as power plants, waste treatment facilities, and highways. One notable example is the Likupang Solar Power Plant project in Indonesia, where the BOOT method, which was implemented in 2019, has been instrumental in harnessing solar energy to mitigate climate change impacts. It allows Independent Power Producers (IPPs) to develop renewable energy projects, such as the Likupang Solar Power Plant, with a capacity of 15 megawatts. The power purchase and sale contract lasts 20 years under BOOT, and the plant has been operational since September 5, 2019. Throughout this timeframe, the private entity supplies the electricity generated to the national grid or a utility company, such as PLN in Indonesia, under a power purchase agreement (PPA). At the end of the concession period, power plant ownership reverts to the government or the public sector. Various climate funding options are available in Indonesia to fund projects and actions related to climate change. These options consist of:

Equity Instruments

Public-Private Partnerships

The framework enabling PPP in Indonesia is robust. PPPs are anticipated to be essential to accomplishing the nation's infrastructure objectives. There are several types of PPPs in Indonesia, including:

· Build-Own-Transfer (BOT)

In Indonesia, Build-Operate-Transfer, or BOT, is a cooperative approach wherein an investor works with the landowner or provider of the asset, typically the government. Under a BOT agreement, a facility or infrastructure project is designed, constructed, and run by a private sector company for a predetermined amount before being turned over to the government. After the agreement expires, the building and/or infrastructure and its facilities are returned. It includes cooperation, provisions, arrangements of rights, and division of obligations between the parties on the utilisation and cooperation with the BOT model, which is not limited to government and private collaboration. The Ministry of Finance of the Republic of Indonesia issued Decision number 248/KMK.04/1995 on June 2, 1995, regarding the treatment of income tax to parties entering into cooperation in the form of build, and Minister of Finance Regulation 96/PMK.07/2007 on Procedure for the Implementation of Use, Utilisation, Write Off and Transfer of State Property regulate BOT. BOT initiatives take a long time and are difficult financially and legally.

· Build-Own-Operate-Transfer (BOOT)

In Indonesia, the government, or another owner or provider of an asset in the form of land, collaborates with investors through the Build-Own-Operate-Transfer (BOOT) scheme. This scheme, which was launched in Indonesia in 2017, is particularly attractive to investors in the renewable energy industry. Under a BOOT agreement, an infrastructure project or facility is designed, built, owned, and operated by a private company for a predetermined amount before being turned over to the government. The private sector's involvement in the project's entire lifecycle, from design to operation, is a key feature of the BOOT scheme. Unlike the BOT system, the private sector controls the project and is not required to transfer it to the government body. Large-scale infrastructure projects like power plants, water treatment facilities, and transit systems frequently use the BOOT concept.

· Build-Transfer-Operate (BTO)

The Build-Transfer-Operate (BTO) programme is an example of a collaboration between an investor and an asset owner or supplier in Indonesia. This entity is usually the government. The BTO is utilised for various infrastructure projects, such as electricity generation, waste management facilities, renewable energy, urban facilities, and more. Under a BTO structure, the private sector partner usually constructs the project assets during the concession period. After construction, the private sector must hand these assets to the government agency. Until the partnership expires, the private sector is entitled to operate and maintain the facility. In this model, public- or government-owned project assets are owned before the project is finished. At this point, the project or facility is rented out to the private sector. The legal requirements for BTO projects in Indonesia are governed by the country's PPP regulations and other relevant laws.

· Viability Gap Fund (VGF)

In Indonesia, the government offers subsidies known as the Viability Gap Fund (VGF) to help infrastructure projects become financially feasible, especially those under PPPs. The VGF is intended to close the gap between the project's potential revenue and total cost, increasing the project's appeal to the private sector. By lessening the financial load on private investors and lowering project viability risks, this fund seeks to make PPP infrastructure projects in Indonesia more appealing. It can be applied to a wide range of infrastructure projects, including, but not limited to, transportation, energy, water supply, and waste management.

The VGF is a component of the government's initiatives to close the funding gap between commercial companies and the government and to promote private sector participation in infrastructure projects. The goal of the VGF is to support local communities socially and economically while making initiatives feasible. The effectiveness of the VGF in encouraging infrastructure investment in Indonesia has been evaluated in terms of its execution. Minister of Finance Regulation Number 170 of 2018 makes this tool possible. It modifies Minister of Finance Regulation Number 223/PMK.011/2012, which deals with facilitating feasibility support for a portion of construction expenses in government collaborative projects with business entities involved in infrastructure.

· Indonesia Environment Fund

The Indonesian Environment Fund, known as Badan Pengelola Dana Lingkungan Hidup (BPDLH), is a governmental entity formed to oversee finances concerning forestry, energy, mineral resources, carbon trading, environmental services, industry, transportation, agriculture, marine and fisheries, and other environmental sectors. Established according to Government Regulation Number 46 of 2017 and Presidential Regulation Number 77 of 2018, it began functioning on January 1, 2020. Its responsibilities include managing funds from various sources, such as international donors and carbon markets, and overseeing various environmental projects. The BPDLH aims to stimulate financial support for environmental initiatives and ensure the sustainable protection and management of the environment. The funds will come from various sources, including land reclamation payments, fines collected from environmental criminal cases, and donations from international partners.

· PT Sarana Multi Infrastruktur (SMI)

PT Sarana Multi Infrastruktur (Persero) (PT SMI) is a government-owned infrastructure financing corporation founded on February 26, 2009, under the Indonesian Ministry of Finance. Its main objective is to expedite national infrastructure progress in Indonesia by executing projects through PPPs and securing funds from multilateral and bilateral financial organisations to support infrastructure endeavours. PT SMI aids in achieving the government's infrastructure development targets and promotes sustainable development and climate resilience in Indonesia by funding projects related to water, renewable energy, transportation, and agriculture infrastructure. PT SMI provides sharia-based financing, investor advisory, project development assistance, and capacity building. It has a sector expansion permit for social infrastructure, tourism, and rolling stocks. The company supports inclusive infrastructure development across Indonesia, focusing on sustainable development and East Indonesian areas, with multilateral and donor institutions.

· PT Penjamin Infrastruktur Indonesia (PII)

PT Penjaminan Infrastruktur Indonesia (Persero), or PT PII, is a government-owned enterprise operating within Indonesia's infrastructure guarantee sector. Established on December 30, 2009, PT PII provides political risk guarantees for central and local governments as a contracting entity in PPP ventures. Its primary aim is to enhance the certainty of private sector involvement and financing for infrastructure projects across Indonesia. PT PII's capacity is further bolstered by its collaboration with international and multilateral institutions. This collaboration ensures that PT PII can guarantee large-scale projects, as evidenced by its guarantees to 50 projects, totalling an investment of Rp. 496 trillion as of November 2023. The company's overarching objective is to facilitate the expeditious development of sustainable infrastructure projects throughout Indonesia.

· Green Bonds

Green bonds represent a financial tool in Indonesia that backs sustainable development and endeavours to mitigate climate change. The Indonesian government has taken measures to promote the issuance of green bonds by public and private sector entities. In March 2018, the Government of Indonesia, facilitated

by the Ministry of Finance, introduced the inaugural sovereign Green Sukuk (Islamic Bond), amounting to USD 1.25 billion. This five-year issuance attracted diverse investors, including conventional, Islamic, and environmentally conscious backers. An infographic report illustrates Indonesia's progression from assessing the country's budgeting system and climate finance monitoring tools to inaugurating the Green Bond and Sukuk Initiative. This initiative bolsters Indonesia's efforts to reduce greenhouse gas (GHG) emissions. The Sukuk is an innovative financial mechanism aligned with Islamic law principles to support Indonesia's commitment to reducing GHG emissions. The issuance adheres to the green bond and Green Sukuk framework, evaluated by international independent reviewer CICERO and granted a medium green rating.

· The Indonesia Infrastructure Guarantee Fund (IIGF)

The Indonesia Infrastructure Guarantee Fund (IIGF) was established in 2009 by the Indonesian Ministry of Finance as a state-owned enterprise. Its primary goal is to enhance the reliability and effectiveness of PPPs for infrastructure ventures within Indonesia. The IIGF offers assurances for the financial commitments of public agencies engaged in PPPs. These guarantees encompass various risks, including non-payment by the public agency, premature termination or default caused by governmental actions or inactions, and unforeseen events (force majeure) affecting the contracting authority. The fund strives to boost confidence in private sector involvement and financing for infrastructure projects in Indonesia by providing these guarantees. It collaborates with international and multilateral organisations to bolster its ability to support large-scale infrastructure initiatives.

4.2 Possible Financing Options

These initiatives and funding alternatives show the various tactics and strategies used by cities in Malaysia, Vietnam, and Indonesia. Stakeholders and local governments can take inspiration from these efforts and modify plans to fit their unique possibilities and problems.

4.2.1 Malaysia

In Malaysia, several funding options are available for climate finance, including domestic and international sources. Some examples of current funding alternatives and initiatives include:

Table 10: Possible Financing Options and the Projects in Malaysia

Financing Options	Projects
Green Sukuk	Solar Photovoltaic Power Plant in Sabah
BOOT	Mass Rapid Transit (MRT) Project in Greater Kuala Lumpur
Private Finance Initiatives	Tanjung Bin Power Plant in Johor
	Kuala Lumpur-Kuala Selangor Expressway

4.2.2 Vietnam

In Vietnam, several funding options are available for climate finance, including domestic and international sources. Some examples of current funding alternatives and initiatives include:

Table 11: Possible Financing Options and the Projects in Vietnam

Financing Options	Projects
Joint Venture	North-South Expressway
	Laos-Vietnam Railway Project (LVRP)
Concession	Hanoi-Haiphong Expressway
Innovation Fund	Water for Women– Women-Led Output-Based Aid (WOBA)
International Development Banks (IDBs) Grants	Climate Resilience of Transport and Water Supply Infrastructure in Vietnam's South-Central Coastal Provinces

4.2.3 Indonesia

In Indonesia, several funding options are available for climate finance, including domestic and international sources. Some examples of current funding alternatives and initiatives include:

Table 12: Possible Financing Options and the Projects in Indonesia

Financing Options	Projects
Blended Finance	Mandalika Special Economic Zone (SEZ)
Green Bonds	Green Komodo Bonds
Ecological Fiscal Transfers (EFT)	Kalimantan Forest Project (KALFOR)
The Indonesia Climate Change Trust Fund (ICCTF)	Makmur Programme
Indonesia Environment Fund	Social Forestry Programme

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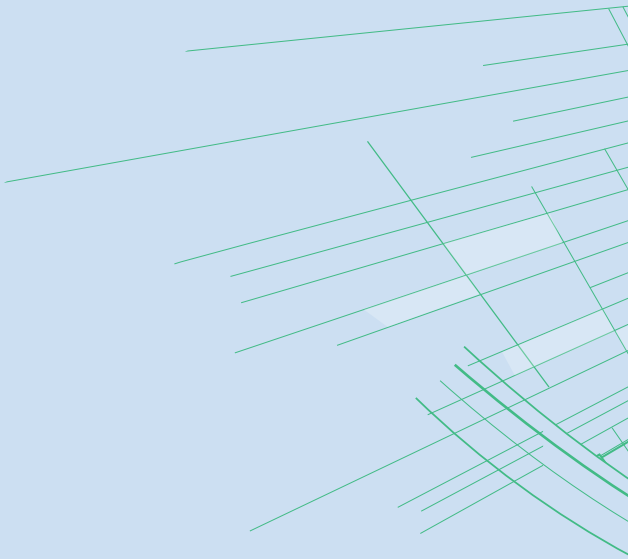
6.0 Annex

Table 13: Interview Guide

1	Would you provide an overview of the programme/project and its primary objectives?
2	What motivated the local authority to initiate this programme/project?
3	What were some of the main challenges encountered during the implementation phase?
4	How has the programme/project positively impacted the local community?
5	How does the programme/project help the city in solving environmental issues?
6	How does the programme/project help the city in solving economic issues?
7	Does the programme/project prioritise support for vulnerable communities?
8	How does the programme/project empower vulnerable communities?
9	How does the programme/project align with the mandates and policies set by the national government?
10	How are the relevant stakeholders involved in this programme/project?
11	Is there a specific budget allocation for this programme/project? If yes, how much?
12	How has the local community responded to the programme/project?
13	How does the city government finance this programme/project? What is its allocated budget?
14	What key lessons were learned from implementing this programme/project?
15	How does the government envision the future of this programme/project in terms of its continued growth and impact?



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