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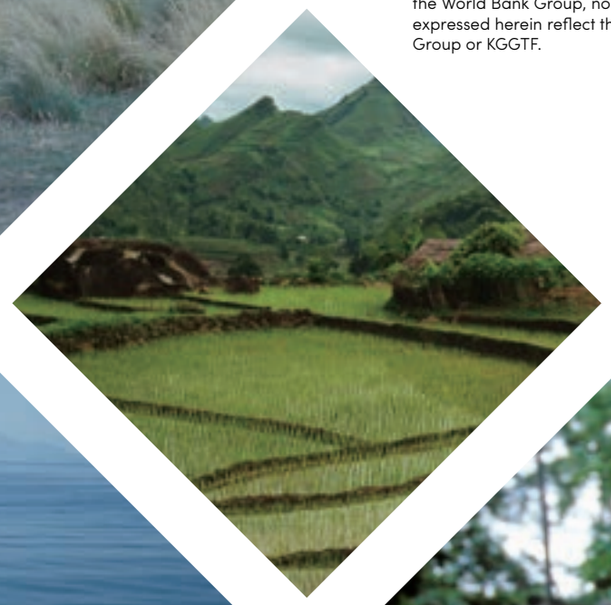
KOREA GREEN GROWTH TRUST FUND 2024 Youth Internship Program Sectoral Report



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YOUTH INTERNSHIP PROGRAM SECTORAL REPORT 2023-2024

This publication is a result of the efforts of the interns participating in the 2024 KGGTF Youth Internship Program. However, it does not represent the work of the World Bank Group, nor do the view or perspectives expressed herein reflect those of the World Bank Group or KGGTF.

2024 Korea Green Growth Trust Fund (KGGTF)

Contact: kggtf@worldbank.org

Chief Editors

Program Manager of KGGTF **Hyoung Gun Wang**
Internship Program Coordinator, Consultant **Jiyon Shin**

Editing Team

Intern **Chaeryun Lee**
Intern **Suhyun Bang**
Intern **Doyun Lee**
Cover page design: **Doyun Lee**

Internship Program Assistance

Consultant **Ire Kim**

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PREFACE

We proudly present this work as a product of the Korea Green Growth Trust Fund's (KGGTF) Youth Internship Program, 2024.

The KGGTF Youth Internship Program was designed to empower the next generation of 'green growth' leaders by inspiring and amplifying youth engagement in green growth, climate change, and carbon neutrality. The six-months internship program consists of lectures and site visits relevant to green growth, aiming to raise awareness, increase exposure, and encourage sustained involvement in green growth endeavors.

The program serves as a pathway to empower youth development, facilitate the acquisition of real-world skills, experiences, and capacity-building opportunities by providing hands-on learning experiences with the World Bank. It also potentially paves the way for professional career development at the Bank and other international development agencies.

While "green growth" can be an elusive concept, it generally refers to a development strategy that aims to ensure continued economic growth while safeguarding the environment's capacity to continuously accommodate human activities without being degraded. Sustainability, a broader concept encompassing economic, environmental, and social pillars, forms the foundation of green growth. However, the ultimate purpose of green growth is to create a better environment and reinvigorated economy for people, in which the "social" aspect is incorporated. KGGTF's numerous grant programs have been serving the world to make continuous endeavors to address countless confrontations between the "environment versus human's economic activity" through mitigation and transformation of the intrinsically conflicting nature into producing favorable outcomes that benefits all.

This report has been created as an exercise for interns to deepen their understanding of the WB's works and to reflect on their analysis of KGGTF's green growth efforts across various sectors including agriculture, digital development, energy, environment, urban, transport, and water. It utilizes KGGTF's grants as case studies to illustrate examples of green growth in action, addressing the challenges encountered in each sector. Written from the perspectives of the youth with a steadfast focus on sustainability, the report also analyzes the limitations for future reference. Despite its limitations as an intern-authored document, this report exemplifies the strong potential of our Internship Program to cultivate the next generation of green growth experts or leaders. The perspectives offered provide valuable insight into the next generation's commitment to sustainability, recognizing that the success or failure of achieving these goals will directly impact their lives in the near future. The proactive engagement and optimism they showed throughout the program underscore their willingness and capacity to tackle such challenges, offering a promising outlook for the future. We trust that the readers will find inspiration in their enthusiasm, as our staff certainly did.

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AFoCO Asian Forest Cooperation Organization

SUDOKWON Landfill Site Management Corp.

K-eco Korea Environment Corporation

SEOUL METROPOLITAN GOVERNMENT

YONSEI UNIVERSITY

EWHA WOMANS UNIVERSITY

Yeungnam University

NAVER

SK ecoplant

TABLE OF CONTENTS

Part 1 Agriculture and Digital Development

1. Introduction 03
2. Digitalization in Agricultural Value Chains 05
3. Case Study A: “Digital Technology for Traceability in Vietnam’s Fruit and Vegetable Chains” 09
4. Case Study B: “Leveraging technology for Uzbekistan’s agricultural modernization” 12
5. Contributions to Green Growth 14
6. Conclusion 16

Part 2 Energy

1. Introduction 20
2. Trends in the Energy Sector 22
3. Best Practices 25
4. Grant Case Study 1: Sindh Solar Energy Program 26
5. Grant Case Study 2: Battery Energy Storage System Development in Pacific Island Countries 30
6. Evaluation 33
7. Conclusion 35

Part 3 Environment

1. Introduction 39
2. Grant Case Study 1: Green Growth Policy Program in Lao PDR 43
3. Grant Case Study 2: Solid Waste Management in the Himalayan Mountains 49
4. Contribution to Sustainable Development and Limitations 53
5. Conclusion 55

Part 4 Urban and Transport

1. Introduction 58
2. Grant Case Study 1: Metro Manila, Philippines 62
3. Grant Case Study 2: Siem Reap, Cambodia 64
4. Evaluations: Contributions and Limitations 67
5. Conclusion 72

Part 5 Water

1. Introduction 76
2. Green Growth and Water 77
3. Case Study: Water Security and Drought Resilience in the South of Angola 80
4. Contributions to the Sustainable Development 83
5. Utilizing the ROK’s Development Experience for Grant Challenges 84

DIGITAL TECHNOLOGY IN AGRICULTURE FOR GREEN GROWTH

: LESSONS FROM KGGTF GRANTS



Sunyoung Ji Na Yoon Kang Suhyun Bang*

ABSTRACT

The agricultural value chain integrates digital technologies to address current issues threatening humanity, including food security, climate change, and food safety. Climate-Smart Agriculture (CSA) approach focuses on the sustainable achievement of the following three main objectives in the international society: (i) increasing agricultural productivity and incomes, (ii) building resilience to climate change, and (iii) reducing greenhouse gas emissions. As best practices of agriculture digitalization in the value chain, Smart HACCP at the food processing stage and the national soil information system at the agricultural production stage are introduced.

The two grants for the digital agriculture transformation in Vietnam and Uzbekistan funded by the Korea Green Growth Trust Fund (KGGTF) of the World Bank are analyzed as case studies. The case study in Vietnam aims to assess its fruit and vegetable value chains and propose digital traceability to enhance food safety. Key technologies adopted in digital traceability are barcodes, IoT sensors, and blockchain. Digital traceability brings sustainability by reducing chemical hazards through cutting footprints and minimizing food waste. Moreover, it contributes to economic growth as enhanced food traceability will build credibility among trading partners and grow its competitiveness in the market. However, they face challenges such as a lack of legal frameworks and institutional capacities. The modernization of the soil analysis method in Uzbekistan aims to enhance its soil information management by modernizing and digitalizing the technologies used in the soil analyzing process and sharing the accumulated soil data for efficient productivity. The modernization of technology is to improve soil quality by less use of chemicals and fertility which affect the environment and green growth. Alongside achieving green growth, it leads to an increased income for the farmers in Uzbekistan and the competitiveness of its crop yield in the global agricultural market. The technology introduced for the program was spectroscopy using Visible and Near-Infrared (vis-NIR) and Mid-Infrared (MIR) to analyze soil quality. However, the technology was not adopted because the country required more foundational institutional reinforcement.

The digitalization of agriculture is inevitable to address the challenges. However, to implement digitalization in the agriculture of developing countries, limitations such as inadequate IT infrastructure, digital illiteracy, costly installation and maintenance, and a shortage of skilled personnel should be resolved. Nevertheless, agricultural digital transformation will be a new business model for the youth with creativity and digital literacy, and it will evolve towards achieving green growth in the long run.

Keywords: The Digitalization of Agriculture, Traceability, Soil analysis

* Sunyoung Ji is a Ph.D. candidate in Saemaul Studies and International Development at Yeungnam University
* Nayoon Kang is a graduate of the MSc Media, Communications, and Development program at the London School of Economics and Political Science. She currently works at the GGGI Communications and Knowledge Sharing Unit
* Suhyun Bang holds a Master's degree in Global Affairs and Policy from Yonsei University, has various work experiences in the private sector and Korean government institutions.

1. INTRODUCTION

The food we eat every day is the final product of the entire agri-food value chains from all over the world. The agricultural value chain has evolved by embracing technology actively to increase productivity. Until now, it keeps transforming to confront the challenges in agriculture that can threaten the entire humanity.

First of all, food insecurity has been always one of the top global issues to be solved. Despite the global efforts to achieve Zero Hunger, as the second goal of Sustainable Development Goals, food insecurity has been more severe. The negative impacts of tackling the achievement are diverse, including conflicts, climate change, pandemics, and inflation. In fact, about 735 million people have suffered from chronic hunger in 2022, 122 million more than in 2019.[1] Global population growth is also a pivotal factor to exacerbate the global food insecurity issue. The agriculture system is expected to meet food production for a growing population that already reached 8 billion in 2022 and will reach almost 9.7 billion in 2050 (Figure 1). [2] Particularly, as the countries in Sub-Saharan Africa and Central and Southern Asia will take the most of the growth of world's population, as the food demand will also rise in these countries which have lower income.

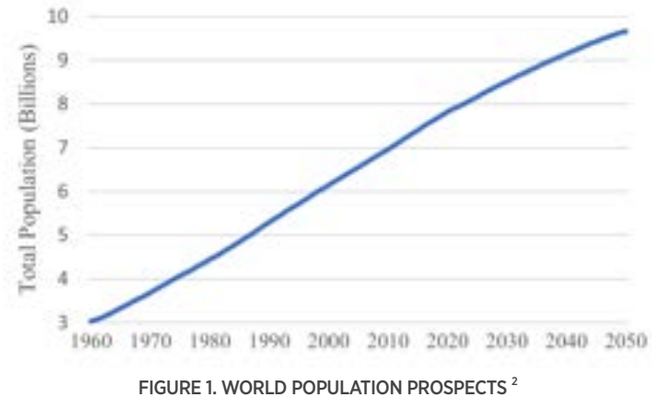

FIGURE 1. WORLD POPULATION PROSPECTS [2]

Nevertheless, acquiring staple grains is not the only issue of food security. Food security is defined when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life from the 1996 World Food Summit.[3] As the global economy grows, the need for meat and dairy will emerge in developing countries. Producing diverse food sources will be another challenge to achieve food security.

Secondly, climate change is considered as a major challenge in the current agriculture sector. Agriculture and climate change are inter-influencing in a vicious cycle. Entire agri-food systems are responsible for accelerating climate change by Green House Gas (GHG) emissions. One-third of all human-made GHG emissions derive from agri-food systems.[4] Especially, the farming stage generates the most GHG emissions (Figure 2).[5] For example, rice farming, upon which half of the global population relies as a staple food, accounts for over 48% of greenhouse gas emissions.[6] Rice paddies generate a significant amount of methane, which is more potent than CO2 in trapping heat.

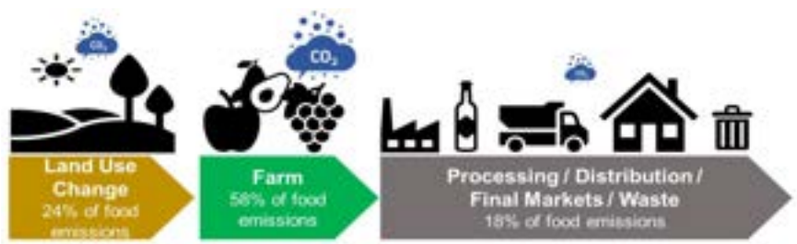

FIGURE 2 GREENHOUSE GAS EMISSIONS OF THE FOOD SUPPLY CHAIN
Source. Climate Everything (2021). Edited by authors.

At the same time, extreme weather conditions such as higher frequency of floods, droughts, heatwaves, and storms caused by climate change severely affect crop production Farmers find it difficult to predict and respond to extreme weather conditions. Furthermore, changes in climate require farmers to consider switching the types of crops they traditionally cultivate. In Korea, due to the impact of global warming, temperate fruit cultivation areas are shifting northward (Figure 3).[7] To adapt to these changes, Jeju cultivates tropical and subtropical fruits such as mangoes and avocados as trials. Sea level rise caused by global warming is also a huge threat to agricultural lands near the seashores. For instance, the Vietnamese government is focusing on developing the Mekong Delta, traditionally a rice farming region, into shrimp aquaculture areas. This shift is due to the increasing salinity resulting from greater seawater intrusion from the Mekong River, making the region less suitable for rice cultivation.

Lastly, food safety is a crucial aspect that cannot be overlooked in the agricultural sector. Food safety refers to the conditions and practices that preserve the quality of food to prevent contamination and food-borne illnesses.[8] By the World Health Organization, internationally an estimated 600 million – almost 1 in 10 people – fall ill after eating contaminated food each year, resulting in 420,000 deaths and the loss of 33 million healthy life years.[9]

Foodborne illnesses are caused by bacteria, viruses, parasites or chemical substances entering the body through contaminated foods.[9] Particularly, current agri-food value chains have more stages to reach the end markets, so agricultural products are more exposed to contaminating environments.

In addition, food safety is closely linked to income generation in rural communities. Most countries import agricultural products which meet quality criteria from the quarantine and inspection regulations to protect their environment from invasive plant and animal diseases but also to keep people's health. To export agricultural products from low-income countries, it is essential to meet international standards by utilizing safe pesticides, fertilizers, and other inputs that comply with these criteria to ensure better quality. Additionally, increased exports can lead to higher economic benefits for households in rural areas.

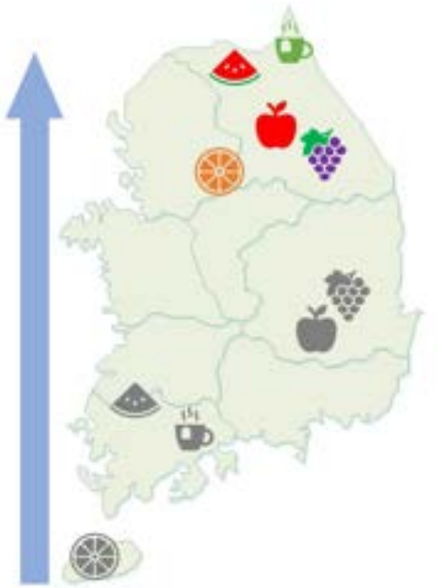

FIGURE 3. SHIFT OF TEMPERATE CROPS IN KOREA [7]

It is true that current agriculture faces complex challenges to overcome. However, despite the critical issues, innovative efforts for green growth in developing countries are also underway. Using the cases of two grants in the agriculture and digital development sector funded by the World Bank Korea Green Growth Trust Fund, this research aims to analyze efforts in agricultural digital transformation to achieve green growth. Two grants to be analyzed in this research are "Digital Technology for Traceability in Vietnam's Fruit and Vegetable Chains" and "Leveraging technology for Uzbekistan's agricultural modernization."

2. DIGITALIZATION IN AGRICULTURAL VALUE CHAINS

2.1. Literature Review

The agriculture has been evolving throughout human history. Singh presented chronological evolution of agriculture from traditional Agriculture 1.0 to modern Agriculture 4.0 and its factors (Figure 4).[10]

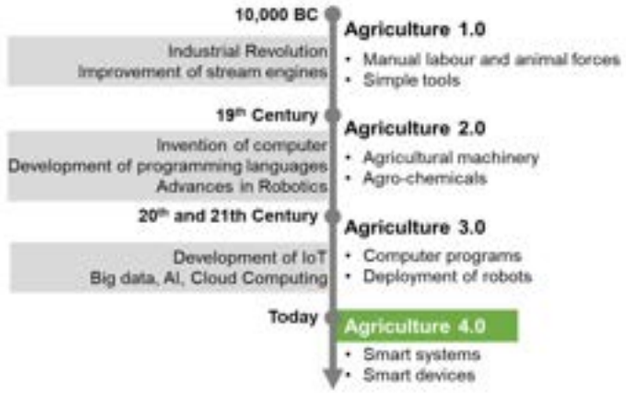

FIGURE 4. DEVELOPMENT OF AGRICULTURE [10]

Agricultural digitization which reflects Agriculture 4.0 has several terminologies based on the objectives and directions of the initiatives undertaken by each stakeholder (Table 1). Even though there is diverse terminology, the consensus regarding digital innovation in agriculture has been made. Thus, many experts in agriculture and international organizations insist on agricultural digital transformation as a solution to overcome the existing challenges in agriculture.

TABLE 1. DEFINITIONS OF DIGITAL AGRICULTURE RELATED TERMS

Organization	Term	Definition
The Organization for Economic Cooperation and Development[11]	Precision Agriculture	An approach to crop management can optimize yields and nutrient use by tailoring inputs to ideal plant growth needs
World Bank Group	Data-Driven Digital Agriculture	Tools facilitating data collection, storage, and sharing throughout the agricultural value chain, leading to improved efficiency and productivity12
IBM[13]	Smart Farming & Smart Agriculture	Utilizing advanced technologies and data-driven practices to enhance sustainability in agricultural production, employing tools such as AI, automation, and IoT
Korea Rural Community Corporation[14]	Smart Farm	Agricultural farms that integrate ICT technologies to remotely control crop growth environments using IT devices such as PCs and smartphones, maintaining optimal conditions based on big data.

Agricultural transformation could commence, due to the emergence of disruptive digital technologies such as blockchain, IoT, and AI. Those digital technologies apply to every stage of the agricultural value chain. Tombe et al. summarized disruptive technologies enabling the digitalization of agricultural value chains (Table 2).[15] The advancement of mobile technology, remote-sensing data, and distributed computing and storage capabilities allows new opportunities to integrate smallholder farmers into the wider agricultural and food system.[16]

TABLE 2. A SUMMARY OF TECHNOLOGOES ENABLING THE DIGITALIZATION OF AGRICULTURAL VALUE CHAINS (AVC) [15]

Enabling Digital Technologies	Technology Applications in AVC Digitalization
IoTs	Coordination, and logistics, quality management, smart farming
Blockchain	Traceability of supply sources and transparency of food sources, food safety
AI	Intelligent farm machines, greenhouse monitoring, drone-based crop imaging, social media and modernization of supply chains, precision agriculture
Big data	Decision-making based on data and sustainable agriculture
Augmented reality	Digital agriculture, precision farming
System integration	Integrated agricultural farm management
Machine learning	Digital agriculture and precision farming, crop disease detection, yield prediction, weed detection, water management, and crop recognition
Edge computing	Big data processing and smart AI applications in agriculture
Cloud computing	Increased efficiency in the AVC
Ubiquitous connectivity	Increasing connectivity along the AVC with the use of different digital devices and platforms to access and share agricultural information

In fact, digital technology is an obvious solution to make agriculture more efficient and sustainable. The World Economic Forum estimates that, if 15-25% of farms adopted precision agriculture, global yield could be increased by 10-15% by 2030, while greenhouse gas emissions and water use could be reduced by 10% and 20%, respectively.[17] This research aims to conduct a case study analysis where digital technology has been applied in agriculture, with the objective of examining how digital technology can play as a solution.

2.2. Key approach in Green Growth of Agriculture

Climate-Smart Agriculture (CSA) is an integrated approach to managing landscapes, cropland, livestock, forests and fisheries that addresses the interlinked challenges of food security and climate change.[18] It aims to achieve three main objectives which are sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change; and reducing greenhouse gas emissions.[18]

CSA necessitates the active participation of smallholder farmers at the grassroot level to deal with challenges directly impacting agriculture. Practices and technologies to implement depend on the level of farmers and farming conditions. Generally, practices such as, water, nutrient, and pest management, cultivating climate-resilient crops, and restoring degraded lands are adopted and digital technology is a significant tool for higher efficiency.

There's broad consensus in the development community on the importance of CSA and this leads international organizations to scale up their investment via policy and technical supports. The World Bank's financing for CSA has increased by eight times to almost $3 billion annually since the adoption of the Paris Agreement.[13] For example, the World Bank launched a program called 'the One Million Hectares Project' to transform the rice industry in Vietnam cooperating with the International Rice Research Institute in 2023. The program will contribute to achieving the Vietnam government's commitment at COP 26 for Net Zero by 2050 but also to increase productivity and quality of rice.

Also, this consensus for achieving CSA includes the private sector, and allows the emergence of outstanding AgTech startups with disruptive digital technology. Innovative AgTech contributes to transform traditional agriculture practices into a way of sustainable growth by embracing farmers to be accessible to CSA practices with their own mobile devices.

2.3. Best Practices of Digitalization in Agricultural Value Chains

The research introduced two best practices in digital application that are effectively embedded in the stages of the agricultural value chain. Two best practices aim to enhance market competitiveness and decrease harmful environmental effects by using disruptive technologies such as blockchain, IoT sensors, similar to KGGTF's grant programs funded in Vietnam and Uzbekistan.

Among two best practices, the first one to be introduced is the Smart HACCP which demonstrates its positive effects of digitalization at the food processing stage in the government-led food safety management system. The Smart HACCP is related to the KGGTF grant program in Vietnam which titled "Digital Technology for Traceability in Vietnam's Fruit and Vegetable Chains" because both contribute to achieve food safety and market competitiveness of the product by applying digital technologies. Additionally, as the other best practice, Korea's Soil Information System is highlighted. It shares a similarity with KGGTF grant program, "Leveraging technology for Uzbekistan's agricultural modernization" that both concentrate on reducing environmental pollution and increasing productivity at the production stage of the agricultural value chain.

This chapter will present two best practices which are the Smart HACCP and Korean Soil Information System how innovative digital technologies are adapted to the production and processing stage of the agricultural value chain, also how digital technologies contribute to achieve green growth.

2.3.1. Smart HACCP

HACCP (Hazard Analysis and Critical Control Points) is a global management system that acquires food safety through the analysis and control of biological, chemical, and physical hazards from raw material production, procurement and handling, to manufacturing, distribution and consumption of the finished product.[19]

In 2022, Korean government implemented Smart HACCP system to enhance management efficiency and reliability by applying innovative digital technologies among agri-food enterprises.[20] Korea Agency of HACCP Accreditation and Services addressed that there are global digitalization trends in the food industry to deal with the food safety issue by embracing IoT, AI, and big data.[21] The US established a policy called 'New Era of Smarter Food Safety' which monitors imported products and sets up a traceability system. EU, also, released 'A farm to fork strategy' in 2022 to adopt smart systems at packaging and distribution stages.

Smart HACCP integrates with IoT and sensors which allow the real-time monitoring at critical control points such as temperature and humidity. Furthermore, collected data from IoT sensors is automatically delivered to the online server so it can prevent from falsification. Digitized management system allows employees access to control the processing stages regardless of location and time constraints. Smart HACCP is increasing food safety, higher efficiency and quality. Consequently, the international competency of Korean agri-food products will rise.

2.3.2. Korean Soil Information System

Korean Soil Information System is an open portal that provides comprehensive soil and agricultural environmental information databases produced and distributed by the Rural Development Administration (Figure 5).[22] The system was completed with 35 years of efforts on soil environmental information surveys since 1964. Plus, diverse soil related agricultural analysis for production is offered; soil information, crop suitability analysis, fertilizer recommendation, and soil monitoring.

This internet-based system enables any users to access soil information to search adequate soil characteristics for their crops and provides recommendations for crop cultivation. Soil information supports farmers in enhancing their agricultural competency by providing assistance in producing safe agricultural products. Plus, farmers can increase crop productivity by measuring precise fertilizers and selecting adequate crops based on accurate soil data.

South American countries evaluated the Korean soil information system as a model case, and KoLFACI (Korea-Latin America Food & Agriculture Cooperation Initiative) was established in 2014 as a cooperation initiative that focuses on sharing the knowledge and experiences in agricultural technology among 13 countries in Latin America. Based on a dedicated partnership, Columbia established its first soil information system, 'IRAKA' in 2020. It allows Columbian farmers to gather soil data to increase soil fertility and agricultural productivity.[23]

FIGURE 5. KOREAN SOIL INFORMATION SYSTEM[22]

3. CASE STUDY A: "DIGITAL TECHNOLOGY FOR TRACEABILITY IN VIETNAM'S FRUIT AND VEGETABLE CHAINS" [24]

3.1. Overview

One of Vietnam's pressing concerns has been food safety regarding public health, socioeconomic development, and international relations. 81 cases of food poisoning occurred between January and November 2021 and this affected 1,942 individuals as well as resulting in 18 fatalities.[25] According to the analysis from 2010 to 2020, the primary causes of food poisoning were microorganisms, natural toxins, and chemicals. Small-scale production also significantly challenges food safety management in terms of risks in farming, production, distribution, and consumption practices. Thus, this case study notes that traceability is the key to managing food safety, allowing the country to trace food, feed, and ingredients back to their origins. The Ministry of Agriculture and Rural Development of Vietnam also has sought traceability as the necessary element and solution in developing the food and vegetable processing industry in 2021-2030. They believe this will allow the country to build and ensure the quality and food safety of Vietnam's food and vegetable supply chains.

The main objectives of this case study were to assess the current traceability systems in Vietnam's fruit and vegetable value chains, evaluate relevant policies, analyze international best practices, and look into China, the European Union, Italy, and South Korea as the biggest export markets. Then it will seek to provide recommendations and insights for Vietnam's F&V value chains in terms of food safety by promoting the concept of digital traceability.

3.2. Stakeholder Roles and Involvement

3.2.1. Government

The Vietnamese food safety-related framework and policies pose responsibilities to three key ministries, especially highlighting the supply chain sector. The Ministry of Health (MOH) supervises overall food safety in terms of functional foods, packaging materials, and packaging processes. The Ministry of Agriculture and Rural Development (MARD) oversees to secure the agricultural, fishery, and agroforestry products' safety. The Ministry of Industry and Trade (MOIT) takes charge of retail food marketing, specific extra products, and supermarket management. Within the local level, committees of provincial and city people are envisioned through planning, organizing, and implementing food safety post-inspection frameworks. Departments of Agriculture and Rural Development (DARDs) and Departments of Health distribute circulars, implement programs, and conduct inspections where food traceability steps in as well. The Ministry of Science and Technology (MOST) take part in enhancing technical standards for food traceability through international benchmarking.

3.2.2. Private

The private sector is also actively involved in Vietnam's traceability systems depending on varied distribution channels. As evaluating the current state, export-oriented firms which use the formal channels have adopted traceability systems. However, small-scale farmer households where businesses are using informal channels lack robust systems. It is important to note that the private sector has shed light on prioritizing data protection and compliance with globally set-up standards like HACCP, Kosher, and ISO 22000. Below are the private companies that have implemented traceability systems.

Lavifood

Lavifood is a key exporter that uses advanced technology stacks and complex traceability systems. Provided with a front-end website and mobile application followed by middleware such as ERP, ICT cloud system, artificial intelligence, and a data and protocol layer with blockchain. The advanced technology stacks also include a QR code system, IoT sensors, and blockchain. The complex system brings in smooth synchronization with the factory's systems, reliability based on blockchain, and interoperability while ensuring the security of the stakeholder's information through a cloud-based system. It is notable that even though Lavifood's products are certified by a global quality evaluation, it has limitations in how it is not highly accessible to the small-scale farmers out in the informal markets.

Queen Dragon Fruit

Queen Dragon Fruit is the largest dragon fruit exporter in Vietnam utilizing a comparatively simple traceability system. Every box filled in with dragon fruits is stamped with a code where information on the exporter name, internal tracking code, batch, and more are embedded. The information is accordingly recorded in the document and archived in the database for tracing. Notably, this process and system is more accessible and applicable in both formal and informal markets while the tracing and recording is proceeded manually. Data protection is implemented by restricting access to the database.

Vietnam Cooperative Alliance (VCA)

One of the socio-economic organizations, the Vietnam Cooperative Alliance (VCA) has developed the traceability system which holds both simple and advanced technology systems. With a front-end including website and mobile application, middleware including data and protocol layer with a blockchain database, QR codes as the base infrastructure, and ICT cloud system, the traceability system touches the different base of the technology. The targeted users are for the export markets, especially the EU and China and it secured the reliability to ensure that the system is compatible with global standards and that changes cannot be made without alerting other stakeholders in the supply chain. The limitation of the traceability system built in VCA is that the usage of the website and smart devices could be challenging to small-scale farmers in the informal market.

3.3. Highlights of the Technology

Traceability is a key driver for strong food safety management. It is organized under regulations to seek consumer well-being and underpin claims like organic, halal, and more. Fundamental elements of traceability in the food industry are broad comprising brand protection, regulatory compliance, and competitive advantage. Increasing attention to environmental, social, and governance (ESG) concerns is leading to recognizing the importance of traceability in global food chains. Despite the term 'traceability' has various definitions across different sources, every definition encompasses the meaning of tracing the history, location, and application of the food product. Especially, Vietnam Law on Food Safety defines traceability as tracing the formation and circulation of food in one whole process. It emphasizes the safety and integrity of the product in every single stage which involves production, distribution, and selling.

Also, this section will introduce three digital technologies that are recognized as the key drivers in the traceability system and also highlight the current states in application to Vietnam's food supply chains regarding sustainability.

Barcodes

Barcodes, machine-readable optical data representations, play an important role in traceability systems for food safety as well as stepping up for green growth. From 1D to 2D, the barcode allows the capture of the data in a timely and accurate manner, which enables to share the key information across supply chains in terms of packaged food. As the transition to 2D barcode scanning is currently ongoing, usage of barcode strengths is developed accuracy and cost-effectiveness. Especially, within Vietnam's fruit and vegetable supply chain, barcodes provide a practical and cost-effective system for tracking the foods for small to medium-sized relevant parties in establishment, operation, and maintenance. Regarding the simplicity of obtaining the barcodes and the highly accessed availability of scanning devices, such as smartphones and tablets, barcodes are emphasized for their easy use. Compared to any other advanced technologies, barcode provides a practical and affordable traceability option for the ones who have limited technical knowledge or practical resources.

IoT sensors

IoT sensors, which hardware and software help machine-to-machine communication, automatically collect data from the products that are in the physical state. The data input is conducted without human intervention and this appears to be one of the biggest strengths in the agriculture sector, especially in irrigation and pesticide application. This indicates a remote-controlled nutrition system which will allow less time and energy consuming jobs for the farmers. The IoT sensor also enables to implement data collection and cloud-based storage while integrating with smart devices. Even though the adoption of IoT in Vietnam is not prevalent yet, the application of IoT is sufficiently feasible in farming. The key driver will be the user support ensuring the system's user-friendly operation in which empowerment and capacity building would need to be considered as well. IoT sensors will efficiently and sustainably manage the data in agricultural practices.

Blockchain

Blockchain technology is often adopted in traceability systems, enhancing visibility, transparency, and efficiency while reducing the risk of counterfeits. This could build credibility in food supply chains among various stakeholders and parties. It will ensure swift recalls, lower the risk, and supporting the reduction of illicit trade. Also, blockchain can verify sustainably sourced or organic claims to organize product information. Regarding business-to-business collaboration, contracts, and certifications can also be conducted cost-effectively while protecting the data. Specifically, in the agriculture sector, it manifests high relevance to agriculture supply chains as blockchains can bring security, accountability, fraud prevention, and traceability. Through blockchain data, it will reduce inspection costs saving the budget for the various stakeholders in the supply chain. However, the application of blockchain in Vietnam's food supply chains remains challenging due to technological, operational, and regulatory factors. Swift transition and adoption of the blockchain in Vietnam will be the key to enhancing the food traceability.

3.4. Limitation

Challenges in implementing food traceability in food and vegetable supply chains include four parts. Firstly, the lack of legal and institutional framework in terms of human resources and inspection tools and mechanisms is one of the limitations. Secondly, available digital solutions and platforms are still under the number and a traceability system cannot be implemented widely. Thirdly, organizational capacity building in a country-driven way would be another key factor in successfully implementing food traceability. Currently, financial and technical resources are necessarily needed to strengthen capacities. Lastly, consumer/public awareness in the domestic market would be prominent to not only apply the digital traceability system but also to widely utilize it.

4. CASE STUDY B: "LEVERAGING TECHNOLOGY FOR UZBEKISTAN'S AGRICULTURAL MODERNIZATION" [26]

4.1. Overview

The agriculture and digital program granted in Uzbekistan is to improve rapid soil analysis by adopting modern technology. 20.7 out of 44.4 million hectares (MH) are agricultural lands, including only 4.28 MH of irrigated land. The Government of Uzbekistan has been focusing on its agricultural sector since agriculture is the largest sector of its economy. Agricultural export in Uzbekistan takes up about 20-25% of its total export revenue. It is an extensive portion, and they export more than 180 agricultural products to approximately 80 countries. The government of Uzbekistan has been focusing on the improvement of the agricultural sector through policy reforms. The government implemented the national initiative Five-Area Development Strategy for 2017-2021, which encompasses all economic sectors, including agriculture. The initiative was established for foundational development in the country and society. The country sets its priority on increasing agricultural productivity and enhancing public institutions to reinforce the competitiveness of the agricultural sector. The biggest issue in their agricultural production is the lack of information on its soil, which leads to unified recommendations on the use of fertilizers based on outdated analyses conducted with large tracts of land areas. Agroecology gets overlooked, it is less cost-effective, and it allows the overuse of fertilizers. It becomes a technological improvement barrier hindering the agricultural productivity of the country.

The soil in Uzbekistan requires adaptation methods since it consists of arid semi-desert and desert conditions, which are calcareous and saline. 79% of its agricultural land is low-productive and water-deficient. The government of Uzbekistan implemented the initiative to modernize technologies for soil laboratories that will strengthen the soil laboratories network in the country. Uzbekistan was advised to join the Global Soil Laboratories Network (GLOSOLAN). GLOSOLAN was established within the framework of the Global Soil Partnership (GSP). GLOSOLAN offers Standard Operating Procedures (SOPs) to integrate its national soil laboratories into an international network since the standardizing methods of soil analysis follow national and international levels. They ensure the consistency of soil analysis methodologies, the professional credentials of soil laboratories, and the effective operation of equipment from purchase to maintenance. The national standards usually include agrochemical services and soil laboratories. The international standards include participating in soil laboratory networks in the GSP system and harmonizing global data of soil analyses. The transnationally shared information leads to accumulated data significant data for countries to define the comparability for exporting technologies, equipment, and fertilizers by considering their properties to meet the acceptable requirements to recommend a product. According to the Rapid Soil Analysis report representing the first phase result, coordinated by Zorya. S.[19]

The program follows four objectives: (i) assess availability/ accessibility/readiness of technologies and institutions for the rapid soil analysis for agricultural purposes; (ii) facilitate knowledge-sharing activities and contribute to setting demonstration sites on using the rapid soil analysis and mapping technologies; (iii) search for promising innovative instruments/technologies for the rapid soil analysis, mapping, and development of recommendations on applying the international practices that could be presented and demonstrated in Uzbekistan; and (iv) monitoring of pilot programs, their evaluation and providing recommendations for institutional strengthening in Uzbekistan.

4.2. Stakeholder Roles and Involvement

4.2.1. Government

The Uzbekistan government supports farmers and financially engages in public soil laboratories and equipment to conduct soil analysis and suggest recommendations for the farms and landowners. The government has been following the Agriculture Development Strategy of Uzbekistan for 2020-2030, for soil fertility and conservation. These activities are to contribute to sustainable development and green growth. The multiple government agencies including the Ministry of Economy and Industry, Ministry of Investment and Foreign Trade, Ministry of Agriculture, State Committee for Geology, and State Committee of Uzbekistan for Land Resources, are assigned with distinguishing roles. Monitoring the status of irrigated land reclamation is conducted by the Hydrogeological and Meliorative Expeditions (HGME) at the Ministry of Water Resources (MWR) of Uzbekistan. The monitoring indicates soil salinity, groundwater level, groundwater salinity, irrigation water, and drainage water, as well as technical oversight of inter-farm drainage infrastructure.

4.2.2. Private

AgroCares, a distributor of handheld scanners and mobile apps, led the spectroscopic soil analysis to participate in the Global Soil Laboratory Network. National reference laboratories are the soil laboratory at the State Unitary Enterprise Analytical Center for Soil Quality, Composition and Repository at the Goskomzemgeodezkadastre, and soil labs of the Research Institute of Soil Science and Agrochemistry and Tashkent State University.

4.3. Highlights of the Technology

Soil fertility depends on features such as pH, electrical conductivity and total soluble salt content, texture, contents of organic carbon (humus), total and available nitrogen, available potassium, and phosphorus; CEC and exchangeable cations; extractable microelements; calcium carbonate and gypsum content. The "Wet Chemistry" technology is a traditional method to analyze soil components, which is common in national standards. However, it is a time-consuming and cumbersome process and hazardous to human health due to the use of harmful chemicals. It is also valid for several other international and national standard techniques for soil analysis. The modern technologies for soil analysis are the Dumas dry combustion method (CHNS-autoanalyzer), Inductively coupled plasma atomic emission analysis (ICP-AES), Atomic absorption spectrophotometry (AAS), Ion exchange chromatography (IEC), X-ray fluorescence analysis (XRF). Equipment to conduct soil analysis requires several conditions, including lighting, ground vibrations, and distance from flammable facilities. The technology adopted for soil spectroscopy in the case of Uzbekistan utilizes visible and near-infrared (vis-NIR) and mid-infrared (MIR) reflectance spectroscopy. This rapid and affordable technology is an alternative to the wet-chemistry method.[27] The electromagnetic (EM) spectrum is comprised of gamma rays, X-rays, ultraviolet, visible, infrared (near, mid, and far), microwaves, and radio waves. The X-ray detects absorption, transmission, and reflection of EM energy on the soil surface.[28]

Agricultural technology modernization for rapid soil analysis aims to gather status information on the soil samples and further measure soil organic carbon stock such as soil carbon sequestration and crediting. A soil spectroscopy approach founded on field-level analysis of soil spectra applying infrared sensors (e.g., AgroCares Scanner, ASD FieldSpec HandHeld 2) or X-ray radiation (EDX XRF III spectrometer, Bruker S1 Titan, etc.) is one of the examples of such technologies. These methods provide rapid and cost-effective analysis of macro- and microelement content in soils, hence contributing to better soil management and higher yields. AgroCares mobile applications offer services, including monitoring, quality data analysis, personal farm management recommendations, and a global community for farmers. The application requires a smartphone and mobile internet to utilize the service. Semtech provides the drill and drops probe that buries underground and collects data regarding soil moisture and temperature for all crops, such as vegetables, fruit, nut trees, vines, and berries.

4.4. Limitation

The main impediments to the broad adoption of rapid soil analyzing methods for monitoring soil quality is the security matter on the use of precise soil maps as well as constraints on using unmanned aerial vehicles such as drones. Moreover, public, academic, and private sectors face challenges that restrict their activities. First, utilizing outdated equipment in conducting reliable quality soil analysis has difficulties due to institutional complexity. Second, capacity building and development encounter difficulties due to financial limitations. Third, the technical and managerial personnel lack adequate knowledge and skills for conducting and analyzing. Last, the farmers lack awareness regarding mobile technologies and tools for climate-friendly agriculture.

5. CONTRIBUTIONS TO GREEN GROWTH

5.1. Digital Traceability System

Developing traceability in Vietnam's food and vegetable supply chains will lead to significant potential for contributing to sustainable development, particularly to green growth. This was also highlighted by the expert in the field during an interview session with Dr. Hardwick Tchale who is the senior agricultural economist of the World Bank, demonstrated in various fields of academia and international development financing. Especially, during the interview the connection between traceability and sustainable development was emphasized. Dr. Tchale shed light on how a developed traceability system can lead to transparency and accountability in the food supply chain which will ensure efficiency at each stage for every supply chain player resulting in reduced greenhouse gas emissions. He also covered emerging end-market trends, such as advanced delivery services and meal kit services through swift digital technology development. He ensured that policies and strategies need to be built to bring in the youth to participate in developing and implementing the digital technologies resulting in innovations that align with green growth.

Regarding the economic and social impacts, Dr. Tchale highlighted how digital technologies are bringing in direct and practical changes such as improving crop yield and quality by the interview. For example, IoT sensors in Vietnam have been enhancing the yield of crops while using water efficiently, which also contributes to reduced greenhouse gas emissions. He acknowledged the challenges and opportunities of implementing digital devices and technologies to smallholder farmers and stated that the digital divide should be addressed while sufficient support needs to be planned for a transition toward utilizing digital technologies. Blockchain was also explored as one of the key digital technologies that could be adopted to enhance traceability. He pointed out that tracking the transformation of food products during the processing stage could be conducted with blockchain even reducing the risk of fraud and ensuring food quality and safety. Moreover, he also shared his insights on the social impacts, such as the empowerment of small-holder farmers, green job creation, and ultimate consumer behavior change. Regarding the policy area, he pointed out how an effective and strategic communication plan is required to enhance public awareness of food safety. To sum up, the expert insight clearly manifested how enhanced food traceability and relevant digital technologies can align with green growth which contributes to sustainable development while considering economic development and social inclusion.

As an expert's insight is valued to study the contribution of food traceability to the green growth concept, this paper also analyzed and reviewed the World Bank's publication titled "Digital Technology for Traceability in Vietnam's Fruit and Vegetable Chains" while integrating the individual's insights as follows. Robust traceability systems will allow farmers to reduce chemical hazards in food production as it will enable every party to track more easily and swiftly. Tracking and monitoring the use of fertilizers and pesticides will lead to better management and will prevent the overuse the of chemical hazards. This will ultimately lead to reduce any potential negative environmental impacts and contribute to cutting the carbon footprints where climate-smart agriculture practices are bolstered. Additionally, enhanced traceability will also play an important role in reducing food waste. Improving visibility across the overall supply chain will result in efficient inventory management and reduce the likelihood of easily spoilt foods being food waste.

Strengthening traceability in Vietnam's food and vegetable supply chains will not only bring positive impacts regarding sustainability but also will enhance Vietnam's export competitiveness leading to economic growth. As international markets were prioritizing transparency and safety in food production and circulation, Vietnam's reputation and competitiveness were comparatively low regarding food safety. Thus, a well-tailored traceability system will build credibility among the trading partners regarding the quality and safety of Vietnamese agriculture products. It will allow Vietnam to be a key player in the global food trade and expand its market access.

5.2. Rapid Soil Analysis

Improving the soil analysis method for the land quality of Uzbekistan will lead to sustainable use of natural resources and ensure food security in the agriculture sector in the country. The program was also elucidated in the interview with the case expert Dr. Sergiy Zorya, the Lead Agricultural Economist in the Europe and Central Asia (ECA) region of the World Bank. Dr. Zorya mentioned that the overuse of chemicals to increase crop yields in Uzbekistan agriculture was caused by the long period of oversight of soil management, leading to stagnated crop harvest and monoculture production. He added that there were no competent foundational institutions to build upon, which led them to establish public land management institutions with the initiation of the Uzbekistan government strategy. Dr. Zorya described that the investment and support from this program, including modernization of soil fertility management and digitalization, were to provide agricultural services for productivity and reinforce market-driven, high-value horticulture value chains. He illustrated that spectroscopy was not adopted in Uzbekistan since they were not ready to apply the technology yet. Nonetheless, they were able to support finalizing the investment plan of the Ministry of Agriculture (MOA) for the soil analyzing and laboratory apparatus and soil information data platform. He also stated that the program increased the awareness of soil health and fertility management and motivated the Uzbekistan government to implement strategies and sector-level policies.

He highlighted that soil information management and soil testing are integrated to develop the Agricultural Knowledge and Innovation System (AKIS), encompassing education, research, and advisory services in Agriculture, and these activities are registered in the Systematic Country Diagnostic and Country Partnership Framework of the World Bank as an analytical work on Green Growth, leading to a new partnership for green growth initiatives with Korea, including MOA and the private sector. He pointed out that the program created e-knowledge to be shared in the global society based on the experience of Korea regarding soil analysis, soil information management, and climate-smart agriculture, already inspiring countries such as Kyrgyz Republic and Tajikistan from the successful experience of Uzbekistan. Dr. Zorya articulated that the program stimulated the Uzbekistan government to improve its laboratory facilities to encourage land and soil management to farmers to motivate the optimal use of fertilizer, cost-effective farming, and curtail environmental impact caused by the soil status.

Enhancing soil testing and analyzing technology to improve soil quality management contributes to adequate use of fertility, preventing overuse of fertilizers that are less cost-efficient for the outcome, considering the use of fertility eventually affects the environment in a negative way. The accumulated data from conducting the soil analysis will strengthen the agricultural precision for its efficiency and productivity, which increases the safety of the food cultivated in Uzbekistan land, leading to increased income and livelihood for the farmers. The accumulated data will also generate soil property maps of Uzbekistan, which will boost its competitiveness in the value chain of the global agricultural food market.

TABLE 3. COMPARISONS OF CONTRIBUTIONS TO GREEN GROWTH

	<Grant A> Traceability Technology	<Grant B> Rapid Soil Analysis Technology
Food Security	- Encouraging farmers to use an appropriate amount of fertilizer for increased productivity - Ensuring competitiveness to expand exports of agricultural products from developing countries	- Enhancing productivity through the selection of crops suitable for soil environments and providing optimal growing conditions
Climate Change	- Restriction on excessive use of chemical fertilizers and pesticides - Controlling production volume through data-based demand forecasting - Reducing product losses in the distribution process	- Restriction on excessive use of chemical fertilizers and pesticides - Ensuring land management for achieving agricultural resilience for the long-term plan
Food safety	- Providing accurate and complete information of products regarding production and distribution to customers - Tracking and monitoring the overuse of chemical pesticides and fertilizers	- Preventing cultivation on contaminated soil - Restriction on excessive use of chemical fertilizers and pesticides

6. CONCLUSION

6.1. Key Lessons

An analysis of two distinct cases insists that digitalization is imperative to achieve green growth by solving current challenges throughout the agricultural value chain, food security, climate change, and food safety in developing countries such as Vietnam and Uzbekistan. Applying digital technology in the production phase enhances agricultural productivity and enables climate-resilient farming practices. For starters, it improves agricultural output by allowing farmers to make data-driven decisions about scheduling, water, fertilizers, and pesticides. Moreover, digital technology in agriculture can contribute to global climate change mitigation by providing optimized practices and smart management for the minimum GHG emissions. At the same time, it benefits climate change adaptation in farming via forecasting upcoming weather and suggesting adequate farmers' activities against extremely changeable environmental conditions. Besides, in the distribution phase in the agricultural value chain, digital technology improves the quality of products with real-time monitoring and easy tracking systems. The improved quality of final products will strengthen the competitiveness of farmers in global trade markets. In the end, strengthened capacity at each agricultural value chain will increase the economic benefits of the entire agro-food stakeholders.

Digitalization in agriculture is a holistic strategy that fosters increased yields, environmental sustainability, and quality. The agricultural sector is required to adopt digital approaches throughout its value chain system to achieve green growth.

6.2. Limitations and Suggestions on Digitalization in Agriculture

Agricultural transformation to digitalization is a spotlighted global phenomenon. However, to spread this trend to developing countries, there are limitations to overcome. Firstly, rural areas, especially in developing countries, often lack internet infrastructure. Disruptive digital technology, including blockchain, AI, and IoT requires a high-velocity internet connection to access online resources, real-time data, and cloud-based applications. Furthermore, digital illiteracy is also one of the main challenges. Many farmers may lack familiarity with digital technologies. Also, limited education and training opportunities on digital devices can hinder their ability to effectively utilize these technologies. For example, Uzbekistan farmers lack the necessary expertise and awareness to use climate-friendly technology. The VisNIR and MIR technologies are quick and non-destructive methods that estimate several soil parameters in a single scan at the same time. They are also inexpensive and ecologically benign, requiring minimum sample preparation and no chemical reagents. Besides, high costs for initiation and maintenance stop developing countries from implementing digital solutions in agriculture that require a foundational investment in devices, software, and infrastructure. Lastly, skilled human resources are not enough in digital technology. Smart agriculture is integrating the latest digital technologies. However, the digital workforce in developing countries is not large, and the level of expertise is not yet high compared to high-income countries. Addressing these challenges requires concerted efforts from governments, organizations, and technology providers to bridge the digital divide, improve digital literacy, and ensure investment in infrastructure and human resources in agricultural digitization initiatives.

6.3. Youth Perspectives

In the flow of agricultural transformation, digitalization is providing the youth with opportunities to create new businesses. Despite the importance of agriculture, it has been one of the industries that the youth are hesitant to engage in. Consequently, the agricultural sector has been one of the latest adopting digitalization. However, it is now considered as the blue ocean of the business market for digital technology. The young generation, leveraging creativity and digital literacy, is inventing innovative technologies that lead the agricultural evolution, as evidenced by the proliferation of AgTech in the world. Nevertheless, the younger generation also needs to focus and prepare for unpredicted consequences. Digital technologies in the food system in Korea, particularly in food-agro product delivery services, are an example. It has given rise to challenges such as the accumulation of leftovers, increased use of plastics, and delivery transportation, which all have negative impacts on the environment. It is desirable for the youth to pursue green growth to achieve sustainable development in the long term rather than focusing on convenience and short-term results when incorporating development with digital technologies.

Agriculture is the oldest industry in human history and an indispensable one. Just as agriculture has continually evolved by embracing the latest technologies throughout history, it will evolve once again by adopting digital technology to address the challenges facing the industry.

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COLLABORATIVE ENDEAVORS FOR GREEN GROWTH IN THE ENERGY SECTOR



Joonyeol Yoon Seoyeon Park Jooeun Kim*

ABSTRACT

This report offers a comprehensive analysis of endeavors to address climate change by advocating for green energy solutions. This article provides an overview of the programs supported by the KGGTF in Sindh, Pakistan, and other Pacific Island Countries. The aim is to emphasize the complex yet essential path towards achieving sustainable growth in the energy sector.

The study begins by establishing the background of the climate problem and the crucial role of the energy sector in both contributing to and mitigating environmental challenges. The article highlights the idea of "Green Growth," which originated in the Asia-Pacific region and has subsequently become a fundamental premise for promoting sustainable development. The focus is on achieving economic growth that is environmentally sustainable, with the goal of increasing substantial environmental preservation.

To achieve "Green Growth," the Sindh Solar Electricity Project in Pakistan's Sindh province seeks to achieve two main goals: increasing the availability of environmentally friendly electricity and encouraging the production of clean energy. The initiative demonstrates the crucial importance of providing technical support, enhancing capabilities, and involving the private sector in easing the shift towards renewable energy.

On the other hand, in Pacific Island Countries, the problem of geographical and fiscal limits requires creative solutions such as Battery Energy Storage Systems (BESS). These systems are essential for ensuring a stable energy supply in areas where standard energy infrastructure is not viable or inefficient. The initiative demonstrates the significance of international collaboration and information sharing in overcoming the distinct obstacles encountered by these island nations in their pursuit of sustainable energy solutions.

The case study also explores the difficulties and restrictions faced. It highlights the ongoing dependence on fossil fuels in certain areas, the necessity of comprehensive legislative frameworks to promote private-sector investment, and the significance of tailoring solutions to local circumstances.

* Joonyeol Yoon is a Master's degree holder in Economics and Environment with a comprehensive professional background and an in-depth knowledge of carbon financing, corporate social responsibility and development.
* Seoyeon Park is a recent economics graduate with background in public finance audit and environment & welfare policy analysis, brings expertise in financial accounting analysis.
* Jooeun Kim is a Master's student majoring in development cooperation with a focus on the Asia Pacific region, offering a strong foundation in sustainable development and political economy.

To summarize, the KGGTF Grant in the Energy Sector serves as a prime example of the diverse strategy needed to attain sustainable economic development. This illustrates that the attainment of sustainable development in the energy industry is possible through collaborative endeavors including governments, the private sector, and international allies. The case study offers unique insights into the strategies, difficulties, and viable methods to go forward in understanding the relationship between climate change, green growth, and the energy sector.

1. INTRODUCTION

1.1. Executive summary

As the climate crisis worsens over time, it has become more crucial than ever to identify environmentally friendly energy solutions. It is crucial to examine the energy sector from multiple perspectives, as it bears a significant portion of the blame for the interconnected problems that arise from climate crises. In eight distinct chapters, this paper will examine current trends and fundamental concepts in power generation, analyze the World Bank Group (WBG) Korea Green Growth Trust Fund (KGGTF) cases, and discuss how the energy sector can confront the current climate crisis.

Chapter 1 will provide an introduction, while Chapter 2 will analyze trends and the fundamental concept of green development in the energy sector. In Chapter 3, essential concepts for comprehending the power sector and best practices apart from KGGTF cases will be elaborated. KGGTF grant initiatives shall be introduced in Chapters 4 and 5. Chapter 6 will then present the grant's contribution to sustainable development, and Chapter 8 will discuss its implications.

1.2. Literature Review

1.2.1. Defining "Green Growth"

In light of the fact that the World Bank KGGTF is an organization dedicated to promoting green growth, it is crucial to define the term "green growth" prior to examining the energy sector. Green growth is a notion that originated in the Asia-Pacific Area. Fifty-two governments and other stakeholders from Asia and the Pacific reached a consensus at the 5th Ministerial Conference on Environment and Development (MCED) in March 2005 in Seoul to embark on a journey of "green growth" rather than merely reiterating sustainable development discourse.[1] A ministerial declaration (the Seoul Initiative Network on Green Growth) and a regional implementation plan for sustainable development were adopted in pursuit of this objective. Each international organization or institute developed its own interpretation of "green growth" subsequent to its emergence. In spite of the divergences, a recurring characteristic has been economic expansion, as measured by the expansion of gross domestic product (GDP), which concurrently yields substantial environmental preservation.

How can "Green Growth" subsequently be achieved? According to a report by Jacob(2012),[2] this can be accomplished through fiscal stimulus in the environmental sector in accordance with Keynesianism, internalization of externalities caused by environmental effects or innovation and industrial policies. Nevertheless, such principles can never be considered "golden rules"; rather, their applicability should vary across diverse circumstances. The report states critics argue that it remains uncertain whether articulating the green growth discourse will assist in reorienting policy debates in favor of the environment, thereby providing an economic counterbalance to the 'anti-environmental' case's well-known arguments regarding employment, competitiveness, and growth. Furthermore, the "green growth" argument is founded on political economy as opposed to economic theory. It is contended that the government intentionally creates victors and losers by incubating or sustaining specific sectors, thereby causing market failures.

1.2.2. Energy and Sustainable Development Goa

A deeper comprehension of the origins of "green growth" can be achieved through an examination of Sustainable Development Goals(SDGs). Eight Millennium Development Goals (MDGs) were established by the United Nations in 2000, prior to the SDGs. Nevertheless, it has faced criticism for failing to adequately reflect the required extent and measure of "Development". SDGs, which are alternatively referred to as the Global Goals, were endorsed by the United Nations in 2015 to promote universal prosperity and peace, eradicate poverty, and safeguard the environment by 2030. As it will be mentioned later in 2.1 The Energy, Food, and Finance Nexus, not only is the crisis interconnected, but each SDG is as well, forming a nexus between them.[3]

The SDG Wedding Cake serves as a visual representation of the significance and interdependence of the ecological, economic, and social systems in the pursuit of global objectives. The Stockholm Resilience Centre introduced the SDG Wedding Cake in 2016. It symbolizes the United Nations Sustainable Development Goals and takes the form of a tiered cake, where each tier corresponds to a different earth system.[4] The Stockholm Resilience Institute initially proposed the SDG Wedding Cake as a means to assert that the SDGs are "directly or indirectly associated with sustainable and healthy food." Nonetheless, it permits the argument that the SDGs are interconnected and dependent on critical earth systems in a broader sense. The three systems symbolized are economics, ecology, and society, with each system being nested or incorporated within the others. This paper will examine in detail how the Affordable and Clean Energy goal relates to the others described in Chapter 7.

FIGURE 1. THE SDG WEDDING CAKE
(Source: Azote for Stockholm Resilience Centre, Stockholm University)

1.2.3. Private Participation

This sub-chapter of the paper examines how key ideas in the energy sector influence private participation. Private participation can be attained through operational levels or financial vehicles.

Independent Power Producers (IPP)

An IPP, short for Independent Power Producer, indicates a non-public utility power facility that generates electricity for sale to utilities or the general public. IPPs are alternatively known as Non-Utility Generators (NUGs). They can be privately-held facilities, cooperatives or non-energy industrial concerns capable of feeding excess energy into

the national electric grid system. In recent years, public utility companies have been actively striving to transfer the responsibility of power generation to the private sector.[5] Power Purchase Agreements (PPAs) safeguard IPPs with obligations to deliver a specific quantity of electricity at a given time. IPPs are extremely beneficial to the energy sector of a nation. They recover their investment in generation technologies through the sale of electricity to end-users.

Competitive Bidding Model

IPP will be selected by competitive bidding model. A prevalent procurement practice, competitive bidding entails bids from multiple vendors for the same material, product, or service in accordance with the organization's specifications. It is frequently chosen by corporations involved in the production of electricity on a significant scale. The organization conducts competitive procurement through tenders, requests for proposals (RFP), and requests for quotations (RFQ), among other methods. Within the time frame provided, the interested parties are required to submit their proposals in response to the tender, RFP, or RFQ.[6]

Public-Private Partnership(PPP)

With regard to investment, the government can alleviate a financial burden by means of Public-Private Partnership. Historically, there has been a lack of adequate government funding and investment especially to expand rural areas' access to renewable (clean) energy.[7] Consequently, in order to achieve zero-net-emissions goals, increasing the capacity for renewable energy production requires PPP investments as a crucial component. As stated by the United Nations, "PPP investments are a voluntary collaborative relationship between various parties, both state and non-state, in which all parties work together to achieve a common purpose or specific task and share risks, responsibilities, resources, and benefits."[8] However, an absolute reliance on investments from the private sector could result in a monopoly of the renewable energy sector.

It is crucial to establish a consortium to participate in more proactive investments across various institutions or businesses. AVPN, the Asian Venture Philanthropy Network, is a prime illustration of this approach. It is the largest impact investing network in Asia. Jong-hyun Lee, the representative of AVPN Korea office, emphasized the necessity of impact investments addressing the current climate problem beyond country borders or sectoral boundaries during an interview with KGGTF interns. AVPN established the APAC Sustainability Seed Fund, supported by Google.org and ADB (Asian Development Bank). The fund mainly emphasizes utilizing technology in various areas like renewable energy/decarbonization, climate change adaptation, biodiversity conservation, water resource preservation, circular economy, air purification, and wastewater management to advance sustainability and combat climate change.

2. TRENDS IN THE ENERGY SECTOR

2.1. Crisis in Energy, Food and Finance Nexus

Recent events have been further derailed in their pursuit to accomplish the SDGs by 2030 due to the convergence of multiple global crises. Commencing in February 2022, the Russian invasion of Ukraine coincided with a period of heightened global economic strain, highlighted by the ongoing recovery from the COVID-19 pandemic and the confronting challenges of an ever more severe climate crisis. A "polycrisis" has resulted from the convergence of these multiple, compounding crises; it has generated unprecedented levels of volatility in the globally interconnected energy, food, and finance sectors and pushed the prices of certain commodities to all-time highs. Particularly, the Asia-Pacific region's energy and food security as well as fiscal integrity have been negatively impacted by the polycrisis, which has pushed millions more people into poverty and jeopardized the region's ability to achieve the SDGs.[9]

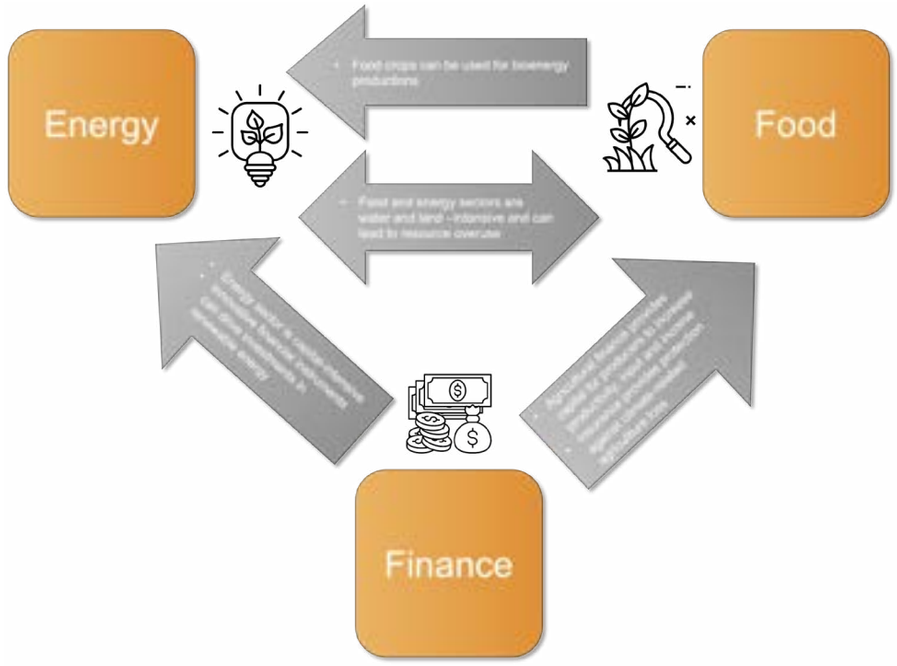

FIGURE 2. ENERGY, FOOD AND FINANCE NEXUS
(Source: UN et al, 2023, designed by the authors)

2.2. International Commitment

2.2.1. Loss & Damage Fund

As the complexity of the energy sector polycrisis increases, international cooperation is required in addition to an interconnected approach. The Loss & Damage fund (L&D) was first introduced in 2013 in conjunction with the Conference of the Parties(COP) 19 in Warsaw, Poland. The declaration for the Warsaw International Mechanism (WIM) was established during this session. The primary objective of the L&D Mechanism is to assist with losses and damages resulting from climate change impacts including both extreme and slow onset events, such as desertification, sea level rise, and ocean acidification, as well as extreme events like hurricanes and heat waves in developing countries especially susceptible to the detrimental consequences of climate change. Supporting vulnerable countries is essentially the responsibility of industrialized nations that are attributed more to the climate crisis. It explicitly specifies three distinct approaches: increasing stakeholder engagement and synergies; fostering comprehensive risk management awareness; and bolstering action and support through the provision of financial resources, technological assistance, and capacity building.[10] However, little progress had been made since then until COP25 reached an agreement to establish the Santiago Network. It occurred as part of the WIM, which concentrates primarily on the technical assistance of pertinent organizations but makes no suggestions regarding the financial means to implement the initiative. Following a second round of emphasis and official endorsement of the fund at COP27, the COP28 bodies reached a consensus regarding the payers and the amount to be contributed. An additional accomplishment of COP28 is the establishment of connections between the fund and the Santiago Network. Nevertheless, a universally recognized framework for quantifying these expenses and establishing equitable mechanisms of sharing among countries is absent. We must reach those milestones to discover the better solution.

2.2.2. Transitioning Away

COP28 has established new L&D fund plan and become the first official statement to address fossil fuel deductions in 28 years, it still holds substantial controversy. After long discussions regarding whether to promote a "phase down" or "phase out" of fossil fuels used for global warming, COP 28 concludes with a call for "transitioning away" from these sources. Despite the subtle distinction in terminology, critics argue that "transitioning away" fails to make a course correction and represents only a small progress over business as usual when the world requires an exponential step-change. "To those who opposed a clear reference to a phaseout of fossil fuels in the COP28 text, I want to say that a fossil fuel phase out is inevitable whether they like it or not. Let's hope it doesn't come too late" the UN Secretary-General added. "Transitioning away" from fossil fuels is not synonymous with "phasing out." "Transitioning away" provides a flexible strategy for selecting green energy technologies, whereas "phasing out" promotes the complete elimination of fossil fuel consumption. Put simply, the phrase "transitioning away from fossil fuels" implies a gradual move towards environmentally friendly alternatives like renewable energy as it does not provide an exact timeframe for the total elimination of fossil fuel consumption. In contrast, the term "phasing out fossil fuels" connotes an organized and planned transition away from these resources, suggesting a systematic and premeditated decrease and eventual eradication of their use. Climate activists and vulnerable nations also advocate for the "phasing out" approach. They say as "transitioning away" provides increased flexibility in the absence of prescriptive measures, the international fossil fuel corporations would continue to operate according to their customary practices.

2.3. Trends in the Private Sector

2.3.1. Renewable Energy 100 (RE100)

The unprecedented inclusion of "tripling renewable energy and doubling energy efficiency" in the final COP28 text signifies the beginning of a massive clean energy revolution, despite the contentious nature of the COP28 outcome as a whole. Initiated in 2014, RE100, which stands for Renewable Electricity 100%, is an international initiative. It is led by the Carbon Disclosure Project (CDP) in collaboration with the multinational non-profit organization The Climate Group. RE100 is a group whose principal objective is to combat the catastrophic global crisis of climate change. It requires businesses to meet all of their essential electricity requirements with 100 percent renewable energy, such as wind and solar power, to reduce greenhouse gas emissions. The sector of power generation is crucial in the effort to reduce greenhouse gas emissions. At present, 427 multinational corporations are members of the RE100 initiative; their annual power consumption exceeds 500 Twh in 2022, which is equivalent to the energy consumption of South Korea, the seventh-largest consumer of energy in the world. Examples from across the nation also demonstrate that this is a viable strategy. Paraguay has already attained 100 percent clean energy since the closure of its final thermal facility in December 2021, it is entirely hydropower. Norway takes a total of 98.3% of its electricity from renewable sources, with 84% derived from hydropower and 13% from wind. It is observed that the geographical location of nations influences the power sources they are able to utilize. Globally, Iceland's electricity grid utilizes geothermal power to the second-largest share in the world (26 percent), with hydropower accounting for the remaining 70 percent. This yields a renewable energy contribution of 96.2% of the nation's overall consumption.

In a conversation with KGGTF interns, Sang-Yup Han, CEO of Sopoong Ventures, emphasised the importance of investing in a reliable electrical grid, ESS (Energy Storage System), and V2G (Vehicle to infrastructure) to achieve a renewable energy-focused city. Regulation within the project's territory can facilitate this investment. He mentioned that the degree of regulatory flexibility in this investment differs among countries. South Korea has officially authorized the use of flexible battery mobility for business activities in accordance with the Distributed Energy Special Law. Several approaches and solutions are currently emerging. In comparison to other advanced countries, this regulation is considered belated, according to him. Particularly, technology for controlling electricity generation nodes through smart inverters and grid forming is becoming increasingly bigger.

2.3.2. Biofuel, "the New Black in Renewable Energy"?

Biofuel is a form of renewable power produced from materials that are derived from microbes, plants, or animals. Biofuels consist of the following: biodiesel (produced from liquid animal fats and vegetable oils), green diesel (derived from algae and other plant sources), biogas (methane produced from animal manure and other digested organic material) and ethanol (often produced from corn in the United States and sugarcane in Brazil). The world expects a considerable increase in energy demand, and it is generally acknowledged that alternative, sustainable solutions are required to meet this demand. Numerous individuals within the energy sector hold the opinion that biofuel may offer a viable solution. They regard it as a vital part of forthcoming energy generation due to its environmentally friendly and renewable features. It is similar in operation to nonrenewable fossil fuels. When ignited, both produce energy that can be utilized to heat residences or power automobiles. The primary distinction between the two is that biofuels have the capacity for perpetual production and, on average, inflict less ecological harm. That is why Exxon Mobil Corporation is among the many major oil corporations in the world that are currently investing millions of dollars in advanced biofuel research. The largest oil company in the United States is allocating the majority of its budget for the creation of advanced biofuels that do not compete with food or water supplies. Specifically, the company is converting plant waste and algae into transportation fuel. Biofuels are regarded by those who are concerned about carbon dioxide emissions and energy security as a feasible substitute for fossil fuels. Nonetheless, biofuels have some disadvantages. For instance, the energy production efficiency of ethanol is comparatively lower than that of petrol, requiring more ethanol to produce the same quantity, and critics argue that the utilization of ethanol is highly wasteful due to its net energy loss and concurrent increase in food prices.

Jong-Hyun Lee, the representative of AVPN Korea, expressed a specific interest in the biofuel business, particularly in connection with renewable energy, during an interview with KGGTF interns. The Voluntary Carbon Market(VCM) sector is closely linked to biofuel, with more than 15% of VCM now sourced from it. He also said that the biofuel industry encounters challenges related to proving food security and the efficiency of emission credits and they are attentively observing the progress in this matter.

3. BEST PRACTICES

3.1. Espejo de Tarabacá (Chile)

This paper examined the method for increasing private participation in 1.2.3 Power Plant by Private Participation. Espejo de Tarabacá may serve as an example. The 300MW pumped-storage hydroelectric power project, Espejo de Tarapacá (EdT), also referred to as The Mirror of Tarapaca, is presently under construction by renewable energy company Valhalla in partnership Fundación Chile (FCh). This is a project funded by Green Climate Fund (GCF). Situated 100 kilometers south of Iquique along the Caleta San Marcos coastline, it will be the first hydroelectric facility in Chile to utilize solar energy for its operational processes. Two commercially integrated power plants constitute the Espejo de Tarapaca project: (1) a 300 MW pumped storage hydroelectric plant with the Pacific Ocean as its lower reservoir; and (2) a 561 MW photovoltaic solar plant.

The pricing on the Chilean energy market is distinctive in that it fluctuates throughout the day exposed to spot market price. Numerous renewable energy initiatives face intermittent challenges wherein the unpredictable nature of spot market prices can significantly impede progress, especially in the case of solar power plants that function exclusively during daylight hours. By providing a "renewable baseload solution" at a competitive price, the initiative will set a precedent. Additionally, it will aid in climate change adaptation by ensuring that vulnerable local communities have access to a consistent water supply sourced from its desalination facility.

The USD 1.1 billion remaining investment will be financed by private sector debt and equity investors, which will be enticed by the USD 60 million anchor equity investment made by the GCF. The private sector debt includes a co-financing loan of 647 million USD and co-financing equity of 386 million USD.

3.2. Sihwa Tidal Power Plant (South Korea)

On the other hand, the Sihwa Tidal Power Plant serves as an exemplary case study in which a power plant effectively tackled the interconnected crisis discussed in 2.1 Crisis in the Energy, Food, and Finance Nexus. Its construction was completed in 2011 and it is the largest tidal power plant to date and the first of its kind in Korea. The generation capacity of the plant located at Shihwa Lake is 254 MW, which is sufficient to supply electricity to an estimated 500,000 households in the surrounding area. Annual power production at the facility amounts to 552 million kWh.[11]

The implementation of the Shihwa Tidal Power Plant project has yielded dual benefits: reduced carbon dioxide emissions via environmentally sustainable energy generation and enhanced water quality in the lake due to consistent circulation. Prior to the construction of the facility, the Chemical Oxygen Demand concentration in the lake exceeded 4 ppm, classifying it as a level-3 body of water—the most severe condition of water quality. The lake obtained the name "Dead Lake" due to the decomposition of its mud surface and the subsequent destruction of its ecosystem. Currently, however, it is undergoing a transformation into an eco-lake, with water being circulated twice daily during ebb tides through the eight sluices of the tidal plant. Around 147 million cubic meters of saline are exchanged during these periods, which is equivalent to roughly fifty percent of the lake's volume. Shihwa Lake's current Chemical Oxygen Demand level of 2 ppm is comparable to that of the West Sea (Yellow Sea), suggesting an improvement in water quality, as it has decreased from 3.7 ppm previously. Furthermore, the process of water circulation within the lake has resulted in the formation of fresh mud plains in the upstream region, which was previously submerged as a result of the embankment. The establishment of these fresh mud flats is furnishing habitats for an array of organisms, consequently converting the lake into a sustainable and vital environment.[12]

In accordance with prevailing trends, the KGGTF also provided financial support for energy sector initiatives aiming to accomplish multiple goals. Chapter 4 will introduce the initiatives funded by the KGGTF.

4. GRANT CASE STUDY 1: SINDH SOLAR ENERGY PROGRAM

The mission of the energy sector encompasses both the development of green energy and the effective supply of these energy resources. The WB grant program implemented in Sindh, Pakistan, aimed to enhance both the facilitation of green energy and the large-scale provision of electric energy.

The WBG and the KGGTF allocated grant (K-113) to the government of Pakistan to facilitate the transition to green energy in the national energy sector. This initiative, titled "Renewable Energy Scale-up to Support Green Growth in Pakistan" or "Sindh Solar Energy Program" (SSEP), commenced in FY 2017 and has been recently extended to FY 2025. The grant, with a total budget of $356,443, incorporates two subprograms. One is associated with a $100,000,000 loan, aiming to promote clean energy generation (P159712), while the other concentrates on advisory services and analytics, providing technical assistance (P169313).

4.1. Client Country Analysis

Increasing energy supply extends beyond building energy plants and cables; it necessitates enhancement at every stage of the energy supply chain. This section of the study analyzes necessity of the grant program by listing challenges and possibilities of Pakistan's energy supply system.

4.1.1. Heavy reliance on imported fossil fuel in power generation

Pakistan is experiencing a historical crisis in its energy sector. The economic loss resulting from electricity shortages was estimated at $17.69 billion, constituting approximately 6.5 percent of the GDP in FY 2015.[13] These frequent energy shutdowns have proven to be a significant hindrance to attracting foreign direct investment.

According to the *Statistical Review of World Energy 2022,* primary energy consumption in Pakistan in 2021 reached 3.86 exajoules. The energy mix was dominated by gas at 41.7%, followed by oil at 26.4%, coal at 17.4%, hydroelectricity at 9.35%, nuclear at 3.6%, and other renewables at 1.3%.[14] Fossil fuel production in Pakistan falls significantly short of demand. The share of domestic production in primary energy consumption was 57.5%, rendering Pakistan highly dependent on energy imports, which constitute 86% of the commercial energy supply. Despite a 60% increase in total electricity generation in Pakistan over the past decade, the growth in total electricity demand has outpaced supply, covering only 60% of the total power demand. In 2013, cities in Pakistan reported electricity shutdowns for 14 hours a day.[15] In 2021, thermal power plants contributed approximately 59% of electricity production, hydroelectric power plants accounted for 26%, nuclear power contributed 10.5%, and renewables made up almost 5% of the overall electricity generation balance. This is a significant shift from 2010 when the amount of electricity generated from renewables was about six times lower. Despite the surplus in electricity generation, fossil fuel usage in the process, often imported, has resulted in fiscal deficits.

The WBG estimates that Pakistan could save $13 billion by shifting towards green energy, particularly by utilizing hydro-meteorological power as the primary source of electricity generation.[16] This underscores the critical need for the grant program to address the challenges and reshape Pakistan's energy landscape.

4.1.2. Lack of technical capacity to maintain effective power transmission system

Power generation is a key industry that supports infrastructure and industry of an economy. Given its high fixed costs stemming from technology-intensive facilities and land acquisition, the energy generation market often takes the form of an oligopolistic market, with governments being the major suppliers in many parts of the world. This structure places a considerable burden on public finances. In Pakistan, the power transmission system also takes on the characteristics of an oligopolistic market, with only five transmission suppliers, all government-owned.

Despite the initial expectations of the government when it opened up its energy industry to private, the energy generation market in Pakistan faces challenges. The subsidies intended for energy plants ended up being predominantly directed towards fossil fuel subsidies, as foreign direct investment in renewable energy proved insufficient. Moreover, the state of electric grids and other issues contribute to large distribution losses, exceeding 17 billion kWh per year.[17] This underscores the imperative need for significant reconstruction and additional equipment in power generation and distribution capacities. Frequent energy theft from local cables is another pressing issue that necessitates an enhancement of institutional capacity to address and mitigate such losses. The complex dynamics of the energy sector in Pakistan highlight the multifaceted challenges that need to be tackled comprehensively for sustained improvements in the efficiency and sustainability of the power supply system.

4.1.3. Lack of institutional capacity in distribution and tariff collection for retail supply

Inefficiencies in Pakistan's electricity distribution companies, including outdated metering practices, low collection rates, technical losses, widespread theft, and gas leakages due to poorly maintained pipelines and sabotage, contribute to challenges in the energy sector. The government imports and buys electricity from these entities at higher prices during disruptions in the value chain, distributing it through a fixed-cost system.

Pakistan has the highest subsidies on energy products in South Asia, with governmental transmission companies sourcing energy from plants, including Independent Power Producers (IPPs) subsidized using public funds. This escalates the fiscal burden, as energy subsidies accounted for 2.6 percent of the country's GDP in 2020.[18] Two-thirds of these subsidies are directed towards electricity consumption, while the remainder is allocated to natural gas.

Despite this substantial financial commitment, the notified tariff remains below the cost recovery level, perpetuating the challenge. Subsidies extend to 62 percent of residential and all agriculture consumers, contributing to the fiscal deficit due to the absence of cost-reflective tariffs. Operational and technical inefficiencies within state-owned electricity and gas distribution companies further compound the issue, as revenue collection falls short of covering the full cost of energy supply. This financial strain is exacerbated by the fact that only 79% of the population has access to electricity, with rural areas enduring twice the duration of electricity shutdowns compared to urban areas.

Despite these challenges, Pakistan has the potential for developing Variable Renewable Energy (VRE) due to geological advantages. The World Bank Group (WBG) and the Korea Green Growth Trust Fund (KGGTF) grant program focuses on scaling up renewable energy in Sindh, addressing these critical issues in the pursuit of sustainable energy development.

4.2. Grant Highlights

The WBG set up four components for the RE scale-up grant. In response to the need of finance and technical assistance, KGGTF in specific provided lending and knowledge product on energy market policy and investment site guide. In this section of the analytical paper, we analyze how each component of the grant directly combats challenges investigated in the prior section.

4.2.1. Boosting total energy generation via energy mix diversification: Component 1&2

The WBG initiated a primary solution to reduce fossil fuel dependency and increase the share of VRE, specifically through the transition from fossil fuel-based power generation to wind and solar power. Aligning with government targets to achieve a 30% share of RE in the total energy mix by 2030, *Component 1: Two utility scale solar park development* focuses on developing two utility-scale solar parks. The primary installation is a 400MW solar park at the Manjhand site, Jamshoro District, utilizing the abundant solar power resources in Sindh. Competitive bidding on VRE plants is also implemented under this component.

In the VRE *Locational Study* funded by the KGGTF, site-specific energy zoning studies were undertaken, recommending the development of large-scale hubs across the country. Balochistan, with its excellent solar and wind resources, is identified as a potential energy hub with the lowest per-unit cost for wind power, contingent on grid infrastructure development. Khyber Pakhtunkhwa (KPK) is deemed suitable for medium-scale wind and hydro-power generation. Punjab, despite challenges in land availability due to extensive agriculture, possesses excellent solar resources, particularly in southern Punjab, offering opportunities for solar power plant development. Sindh, a major focus in the SSEP, boasts excellent solar and wind resources in the Jhimpir and Gharo corridors, with significant potential for further wind farm installations. Furthermore, the KGGTF developed a VRE Potential Productivity map, recording viable investment sites for wind and solar power generation. This map offers crucial insights for guiding the government of Sindh and energy investors in strategically selecting locations for optimal renewable energy programs.[19]

Component 2: Distributed Solar (Rooftop PV Pilot program) involves utilizing government buildings for VRE development. In partnership with the provincial government of Sindh, the WBG has commissioned 29 sites, primarily public hospitals, for the installation of rooftop solar panels. This initiative, generating 16.39 MW of energy without land-usage conflicts, exemplifies a sustainable approach to decentralized solar power generation.

4.2.2. Building Technical and institutional capacity for transmission efficiency: Component 4

Component 4: Capacity building and Technical Assistance incorporates long-term initiatives to enhance organizational capacity and reduce energy loss through investments in human capital. The KGGTF spearheads training programs, including a notable initiative training 300 technicians in solar power generation, cable construction, and market-oriented policymaking.

One marketization strategy suggested by KGGTF is competitive bidding, particularly relevant when transitioning from a government-centered energy market to the private sphere. Competitive bidding ensures strategic, transparent, and cost-effective procurement of VRE. *A Competitive Bidding Study,* drawing on international experiences, compared different bidding models. Among them, park-based bidding, targeting large zones with high wind resource potential in Balochistan and Sindh, is recommended. Substation-based bidding is advised for regions with smaller Renewable Energy (RE) sites, focusing on solar power generation. Additionally, technology-specific approaches and site-neutral bidding are proposed options for consideration as RE hub development progresses. The importance of strengthening institutional capacity, including clear bidding schedules and energy demand measurement, is emphasized Proposing *a Current Year VRE Procurement Plan,* decided by the AEDB Steering Committee through consensus, further underscores the commitment to a transparent procurement process.[20] However, competitive bidding for energy generation companies experienced a temporary halt due to extreme flooding in 2022. With the grant extension to 2025, the adoption of the bidding mechanism and the opening up of the Pakistan energy market are anticipated in the near future.

4.2.3. Provision of Solar Home System (SHS) on rural area: Component 3

Component 3: Solar Home Systems(SHS) – RE based rural electrification program aims to provide electricity to areas without access to energy transmission networks by supporting home generation. Typically, household generation entails high production costs for installation and storage systems, as economies of scale cannot alleviate the burden of initial fixed costs. The SHS program is specifically designed to assist individual households in need of affordable and reliable energy. Since late 2021, the WBG has overseen the sales and installations of SHS, with public stakeholders providing grant deductions from retail prices to encourage household solar generation. As of now, 322 SHS units have been sold, and demand is anticipated to rise further during the 2022 flood recovery period in Pakistan.

4.3. Limitations and Policy Recommendations

Despite years of initial implementation of the grant, Pakistan continues to encounter limitations in achieving a green shift in its domestic energy system.

4.3.1. Challenges and limitations

Pakistan's dependence on fossil fuels remains at a high level. In the fiscal year 2022, fossil fuels accounted for 59% of the total energy supply, and fossil fuel subsidies persisted in the subsequent fiscal year.[21]

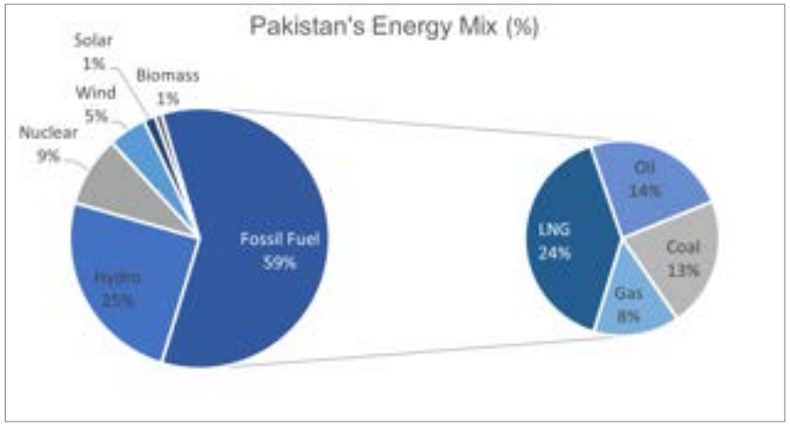

FIGURE 3. PAKISTANS'S ENERGY MIX TABLE

Source: Division of Energy, Pakistan, designed by the authors

Sindh takes a significant role as a major coal producer in Pakistan, contributing to the country's ongoing reliance on coal. The Sindh Engro Coal Mining Co. (SECMC) has ambitious plans to increase coal output by 51.3% in 2024.[22] Additionally, the Pakistan government has unveiled a plan to install a 300MW coal plant in Gwadar. This program is funded by Chinese state-owned entities, including the Industrial and Commercial Bank of China (ICBC), and is positioned as an energy supply hub for the China-Pakistan Economic Corridor (CPEC), currently under construction by the Chinese company CIHC Pak Power.[23]

4.3.2. Policy Recommendations

The Government of Pakistan should actively pursue additional policy actions to enhance the RE industry. Repurposing coal plants in Sindh into solar plants, incorporating best practices gained from the SSEP, can be a strategic move towards a more sustainable energy landscape. Simultaneously, there is a need for reforms in current fossil fuel subsidies, shifting towards subsidies that promote green energy. This dual approach can contribute significantly to advancing Pakistan's commitment to a greener and more sustainable energy future.

5. GRANT CASE STUDY 2: BATTERY ENERGY STORAGE SYSTEM DEVELOPMENT IN PACIFIC ISLAND COUNTRIES

Pacific Island Countries (PICs), grappling with salination and increased cases of meteorological instability, necessitate a robust system for storing overproduced electric energy and utilizing it when needed. In response, the WBG and KGGTF extended a grant to PICs titled Regional E-mobility and Battery Storage Programmatic Technical Assistance (P159712). The approved grant amount totaled $300,000, and after seven years of project deliberation, the grant concluded in February 2023. As part of this initiative, KGGTF collaborated with Korean partners to facilitate knowledge exchange, highlighting successful models of Battery Energy Storage System (BESS) adoption in larger islands.

5.1. Client Country Analysis

Hydrometeorological power generation, reliant on unpredictable elements like sun and wind, faces challenges compared to traditional power sources that can be stored for on-demand use. Solar and wind plants operate based on weather conditions and are susceptible to natural disasters. Governmental transmission companies manage energy prices, shutting down plants with costs exceeding the system marginal price (SMP) during nighttime or offseason to meet demand and prevent overproduction. The uncontrollable nature of renewable energy (RE) plants can lead to energy disposal, especially during moderate weather seasons.

To mitigate such challenges and enhance profitability, the development of Variable Renewable Energy (VRE) battery storage systems, specifically Battery Energy Storage System (BESS), is crucial. BESS facilitates storing overproduced energy for later use, reducing meteorological variance in power generation.

For island countries, facing geological obstacles and high dependence on costly imported fossil fuels, BESS becomes a critical technology. The lack of capacity for energy infrastructure management and data systems poses challenges for energy supply within islands. Geological and economic limitations emphasize the need for market-based RE supply systems in islands. Small territories surrounded by the ocean require land-efficient generation methods but face challenges from fluctuating weather, industrial water supply, and small market size. These factors contribute to high-risk, low-return investments in the energy sector for Pacific Island Countries (PICs), necessitating strategies to hedge inherent risks for long-term investment promotion.

Despite environmental limitations, PICs have set ambitious plans for constructing a low-carbon energy system based on renewables. *The Climate Change Action Plan 2021-2025 (CCAP)* aims to add 20GW in RE generation, doubling current RE investments. The grant from the WBG to PICs aligns with this vision, supporting the transition to low-carbon growth.

5.2. Grant Highlights

Accompanying a $5,660,000 loan to the Pacific Power Association (PPA), the KGGTF initiated knowledge exchange programs and provided policy notes for a regional framework on battery storage and data management.

Component 1: Designing regional EVs policy framework and Technical Guidelines, focused on designing a regional framework and Technical Guidelines, aiding site development by creating a renewable resources potential map, akin to the Sindh case. This resource map serves as a guideline for local governments and investors, providing essential data for effective site planning and investment decisions.

Component 2, the Assessment of Battery Storage Applications in the Pacific Island Countries (PICs), supports the findings of the first component by assessing BESS application models in a site-specific manner. The WBG underscores the importance of private sector participation in advancing green energy, given the fiscal capacity of PICs. Mitigating financial risks through mechanisms like joint finance can reduce investment risks and attract private sector actors. Combining various financial instruments, including concessions, loans, and equity, helps decrease the risk to private investment. Additionally, fostering the ability to promote structured finance could enhance scalability. Forming economies of scale within PICs involves standardizing documents related to energy project financing and consolidating smaller sub-projects into joint green bonds.[24]

The primary program of KGGTF was *Component 3: Support for PPA's regional framework to scale-up EV,* which focused on supporting PPA's regional framework to scale-up EVs. Partnering with Korean provincial governments, KGGTF funded an analysis of BESS deployed in the islands of Jeju-do and Gapa-do as successful development models. Through econometric modeling, the case study on the two Korean islands revealed a positive correlation between daily BESS usage and an increase in VRE power generation, specifically from wind and solar sources.

TABLE 1. COMPARISON TABLE OF TWO KOREAN ISLANDS BASED ON KGGTF REPORT

	Jeju-do	Gapa-do
Energy Mix	Varied source	3 sources
Power Generation form	Central Generation	Dispersed Generation
Grid type	Main Grid	Mini Grid (Microgrid)
BESS dependency of grid	Low	High

The experiences from Gapa-do are particularly relevant to Pacific Island Countries (PICs) that employ a dispersed generation system and mini-grid approach. KGGTF recommends that decision-makers in PICs consider implementing the Gapa-do model as a key component of their domestic policy framework. The insights and lessons learned from the Gapa-do experience can serve as valuable guidance for shaping effective policies that align with the specific energy landscape and requirements of PICs.

5.3. Limitations and Policy Recommendations

While the implementation of Battery Energy Storage Systems (BESS) from Korean islands is anticipated to contribute to the increased usage of Renewable Energy (RE) in Pacific Island Countries (PICs), direct implementation faces challenges arising from geographical, fiscal, and political differences between regions. PICs exhibit a notable dependency on diesel.[25] In this section of the case study, we analyze the remaining challenges and propose further steps for the successful green shift of PICs based on insights from KGGTF's case study.

5.3.1. Challenges and limitations

The geological conditions of Pacific Island Countries (PICs) pose challenges to the widespread usage of Battery Energy Storage Systems (BESS). The Operations and Management (O&M) costs remain high due to a lack of infrastructure and the proximity to the ocean.[26] Another significant factor contributing to the increase in O&M costs is the need to source replacement parts from distant locations. Li-ion batteries, one of the most widely used types of energy storage batteries, struggle to withstand the rising temperatures in PICs.
To address these challenges, PICs require a private investment-friendly policy framework that opens up their energy market to private investors. Devising insurance schemes to protect private investors becomes crucial in forming a sufficient fund to boost the energy sector.[27] This approach aims to attract private investments while mitigating the risks associated with the unique challenges faced by PICs.

5.3.2. Policy Recommendations

PICs should focus on transitioning from diesel plants by leveraging best practices acquired from BESS programs. It is essential to adopt a proactive approach in preparing insurance schemes for the private sector, especially in the context of public-private partnerships (PPPs), despite operating in a high-risk, low-return environment. By establishing such insurance mechanisms, PICs can create a conducive environment for private sector participation and mitigate potential risks associated with their energy transition initiatives.
Drawing insights from KGGTF grants in Pakistan and PICs, three key policy recommendations for small economies aspiring for green growth through Variable Renewable Energy (VRE) facilitation:

- Promote Private Participation
- Utilize Geological Data for RE Productivity Mapping
- Adopt Market Mechanisms for Energy Efficiency
- Build Infrastructure and Policy Framework for Battery Storage

6. EVALUATION

This study employed the SDGs to analyze the contributions of two grant programs in the energy sector by KGGTF. Using the SDG wedding cake model introduced previously, this section will demonstrate the environmental, social, and economic contributions of the two grant programs.

6.1. Comparison of Contributions to SDGs

TABLE 2. COMPARISON OF CONTRIBUTIONS TO SDGS

Program	Environmental	Social	Economic
Grant 1	SDG 13.2	SDG 7.1, 7.2, 7.3, 7.a, 7.b SDG 11.a	SDG 8.3 SDG 9.4 SDG 12.a, 12.7
Grant 2	SDG 13.2 SDG 6.4, 6.a	SDG 7.1, 7.2, 7.3, 7.a, 7.b SDG 11.a	SDG 8.3 SDG 9.4 SDG 12.a

As renewable energy programs, the two grants make contributions to SDG 13 CLIMATE ACTION. From a country level index, they make contributions to "CO_2 emissions from fossil fuel combustion and cement production" and "CO_2 emissions embodied in imports."[28] In addition, they contribute to SDG 13.2 "Integrate climate change measures into national policies, strategies and planning."[29]

As programs from the energy sector, SDG 7 has the closest linkage to the two grant programs. On a country level index, the programs are expected to make contributions to "Population with access to electricity," "CO_2 emissions from fuel combustion per total electricity output," and "Renewable energy share in total final energy consumption".[28] They also contribute to the SDG targets listed below.

7.1 By 2030, ensure universal access to affordable, reliable and modern energy services
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix
7.3 By 2030, double the global rate of improvement in energy efficiency
7.a By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology
7.b By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support

Grant 1 utilizes rural land and Grant 2 program is located on isolated island countries. This makes a contribution to "SDG 11.a Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning." [29]

Both of these programs apply innovative approaches, are expected to create jobs and encourage economic growth by facilitating energy development. These aspects contribute to SDG 8.3 "Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services." [29]

Both of the programs aimed to enhance efficiency in energy usage and adopted green technologies, contributing to SDG 9.4 "By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and sound technologies and industrial processes, with all

countries taking action in accordance with their respective capabilities." [29]
The two grants involved providing technical assistance fostering sustainable consumption and production practices, contributing to SDG 12.a "Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production." [29]

Grant 1 differs from grant 2 in its characteristics due to the adoption of the competitive bidding model. This makes grant 1's unique contribution to SDG 12.7 "Promote public procurement practices that are sustainable, in accordance with national policies and priorities." [29]

Grant 2 can be distinguished from grant 1 in regards to island country-specific contexts of freshwater scarcity and the EV element of the program. In the reference case of Gapa, the energy stored in the ESS was used for desalination. PICs may expect similar utilisation of ESS capacity, contributing to SDG 6 CLEAN WATER AND SANITATION. On the country index level, this contributes to freshwater withdrawal. This also contributes to to SDG 6.4 "By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity" and 6.a "By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies" [29] and SDG 11 country index "Access to improved water source, piped." [28]

In terms of the EV development, grant 2 contributes to SDG 11.2 "By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons" and SDG 9.1 "Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all". [29]

6.2. Comparison of Limitations

TABLE 3. COMPARISON OF LIMITATIONS

Program	Environmental	Social	Economic
Grant 1	Wildlife conservation; additional load on rooftops; damaged solar panels from storms	Cash compensation for resettlements; social conflict and privacy of women	Continued reliance on fossil fuel; coal production in Sindh; fossil fuel subsidies; fossil fuel imports
Grant 2	Remoteness	Lack of legal framework, lack of client country ownership	Private sector engagement; lack of competition in energy market; dependency on imported fossil fuel

This study incorporated the Environmental Social Management Framework (Government of Sindh, 2018) to identify the challenges in grant 1. The first environmental challenge encountered by grant 1 is its impact on wildlife and habitats due to the solar park site's proximity (approximately 30 km) to Kirthar National Park crucial to wildlife conservation.

Grant 1 also faced an environmental challenge from the additional load on rooftops from solar panels which can be dangerous as many government buildings which are to have solar panels installed have aged infrastructure and rural buildings often had no safety regulations.

Lastly, the coastal regions in the Sindh province are prone to severe storms and solar panels can be damaged in these circumstances which results in falling or broken solar panels that can be a safety hazard.

On the social dimension, resettlements have to be made due to the large-scale solar park installation. The GoS[30] has promised cash compensation for resettlements and this process should be monitored with prudence to ensure the rights of relocated residents are fully protected.

In the matter of social conflict and privacy of women, GoS mentions "respecting women's privacy," but does not include women into decision making processes to seek their opinion on the safety concerns regarding the influx of construction workers and rapidly changing environment. This is concerning and GoS should strive for ways to proactively include women and other vulnerable groups in policy making.

From the economic side, Pakistan continues to depict heavy reliance on fossil fuel in its financing such as importing fossil fuel and fossil fuel subsidies. Sindh is also a major coal producer in Pakistan, challenging renewable energy programs in the region.[31]

Based on the World Bank[32] report, this study identifies major challenges in grant 2. From the environmental side, due to the remote conditions of these islands, O&M can be costly to source replacement parts. On the social side, there is a lack of legal framework to support the continuous ESS development, threatening sustainability of the program. Senior energy specialist commented that there was a lack of client country ownership of the grant and it was difficult to convince the client country in adopting renewable energy transition.* On the economic side, there is a lack of private sector engagement due to the high-risk low return environment with no insurance schemes to attract the private sector by protecting their loss. Another limitation was no market competition between utilities because of their mutually exclusive regions of service. Lastly, PICs showed the continued heavy dependency on costly imported fossil fuels.

The common limitation of the two grant programs was the reliance on fossil fuel. Unable to meet the growing demand for energy or establishing stability of the energy supply, both of the regions depended on imported fossil fuels.

7. CONCLUSION

7.1. Summary of Grants

Grant 1 provided technical assistance and capacity building to support the GoS in developing large-scale distribution of solar PV. Grant 1 highlighted that establishing a good early experience in solar PV is important to avoid integration issues. The solar PV infrastructures were also built with climate resilience taking into account that coastal regions in Sindh are prone to severe storms. Emerging markets such as the RE market can be enhanced with competitive bidding.

Grant 2 provided support in designing a regional EV and ESS deployment roadmap in PPA. This program illustrated that BESS development is increasingly becoming significant in RE transition. Private sector engagement was also proven to be crucial in RE development. Most importantly, clear government policies were imperative to attract private sector actors to demonstrate a clear roadmap for investment.

* Comment extracted from WB Senior Energy Specialist, Inchul Hwang, at the Seminar with Senior Specialists at the WB Korea Office, WB KGGTF Youth Internship Program Special Lecture Series, Feb. 2024

7.2. Place-specific Implications

The two grants have exceptional place-specific implications due to their geographical and locational conditions, economic development stage and other factors. Firstly, narrow economies, such as in the case of PICs, can transition non-market to single-buyer market to enhance competitiveness. Secondly, when there is a lack of variety in the energy mix due to geographical limits, BESS capacity is critical to assure the stable supply of electricity. Another important implication for island countries is that ESS can also be used for desalination. Last implication is the land expropriation process and mitigating social conflict in the procedures by establishing a response mechanism in cases of social grievances.

7.3. Universal Implications

The universal implications of the two grants are as the following:

- Private sector's role in green growth is vital.
- Energy mix should be diversified for competitiveness.
- Battery storage is pivotal in variable renewable energy development.
- Reducing energy loss in transmission and overproduction can enhance efficiency.
- Collection fee systems should be optimized to mobilize more private sector engagement with higher returns.
- Insurance schemes for private sector partners should be provided to cope with the large initial investment needed upfront.

7.4. Youth Perspective

The youth today faces catastrophic climate related disasters on an unprecedented scale. This inevitably leads to why the current generation of youth is gravely concerned with climate change and sustainability. Urbanization is shifting to low- and middle-income countries at rapid speed, characterized by low resources, high informality, and climate vulnerability.[33] This poses consequential challenges to the energy sector with energy demand growing on an exponential range and not only is the supply incapable of meeting this enormous demand, it is being supplied in unsustainable and destructive ways.

Chakrabarty found that the modern concept of development has been based on an ever-expanding use of fossil fuel and energy-intensive activities.[34] KGGTF's energy grant programs have challenged this conceptualization by cultivating renewable energy for green growth. While environmental protection and economic growth often came in conflict in national development priorities in the past, the notion of green growth promoted by institutions such as KGGTF is mitigating this contentious relationship by achieving economic growth and environmental protection simultaneously.

Partnership with the private sector is essential in green growth and KGGTF's energy grant programs have showcased best practices in private sector engagement for green growth. Green growth requires coordination across different sectors and multi-stakeholders to implement a holistic development model. KGGTF's energy programs highlighted the importance of coordination to successfully execute green growth programs which provided invaluable lessons to the youth in sustainable development.

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UNLOCKING THE POTENTIAL OF GREEN GROWTH:
LESSONS FROM KGGTF GRANTS



Seoyoung Lee Kyunghwan Choi Seokjun Hong*

ABSTRACT

This paper describes the current environmental status and presents green growth as a key solution to overcome environmental challenges. The emergence of green growth as a novel concept in 2008 highlighted the intrinsic link between environmental sustainability and economic prosperity. However, challenges exist in executing green growth initiatives, including limited knowledge and network opportunities, along with high policy costs. These hurdles should be overcome, and international organizations have played a crucial role in aiding countries in designing and implementing green growth policies. Therefore, this paper analyzes two grants facilitated by the Korean Green Growth Trust Fund (KGGTF), illustrating the collaborative efforts of the international community to streamline green growth.

The Green Growth Policy Program in Lao PDR is a multifaceted program designed to address various environmental challenges prevalent in the region by providing comprehensive policy advisory and analyzes. Through a combination of policy interventions, capacity-building initiatives, and stakeholder engagement, the grants aim to promote sustainable forest management practices, reduce greenhouse gas emissions, and preserve biodiversity.

Through a dual-pronged approach combining waste sampling and qualitative surveys, the Solid Waste Management program in the Himalayan Mountains provides insights into waste generation patterns, socio-economic factors, and stakeholder involvement. Recommendations include promoting biomethanation programs, improving waste collection systems, and implementing large-scale composting, among others. The paper highlights the contributions of both programs to Sustainable Development Goals (SDGs), such as clean water and sanitation, sustainable cities and communities, and climate action.

Despite notable strengths in engagement strategies, innovative financing mechanisms, and knowledge dissemination, both programs face some limitations related to the absence of comprehensive evaluation reports and ambiguity in defining and implementing good environmental practices. In addressing these constraints, proactive measures such as robust regulatory frameworks and efficient data collection mechanisms are essential.

In essence, the paper emphasizes the necessity of tailored solutions and collaborative efforts among stakeholders to achieve sustainable environmental management. It underscores the pivotal role of KGGTF Green Growth strategies in addressing environmental degradation while fostering economic development by showcasing the tangible impacts of these programs.

* Seoyoung Lee majored in urban planning and real estate at Chung-ang University and has a strong background in economics, environmental studies, and sustainable development to catalyze positive change.
* Kyunghwan Choi is passionate about inclusive climate change responses, specifically Loss and Damage, and has on-the-ground experience in Central America and practical involvement in the Arab region.
* Seok Jun Hong studied Economics and Applied Statistics at Yonsei University with a focus on applied econometrics, environment, and social capital.

1. INTRODUCTION

The preservation and fosterage of green ecosystems stand as imperative pillars in the pursuit of sustainable development. The intricate interplay between environmental health and human prosperity underscores the indispensable role of maintaining vibrant ecosystems. At the heart of this endeavor lies an important understanding of the intrinsic value of nature, not merely as a repository of resources but as a foundation upon which societies thrive.

Ecosystems provide a myriad of services essential for human well-being, ranging from clean air and water to fertile soils and climate regulation. However, the relentless pressures of human activity, compounded by factors such as population growth and industrialization, have placed unprecedented strains on these ecosystems. Human society has benefited from the green ecosystem. However, these human activities have jeopardized the environment and obstructed the ability to sustain economic growth in the long term.

Hence, it became increasingly evident that safeguarding these initiatives represent proactive steps towards addressing environmental challenges while simultaneously harnessing the opportunities presented by sustainable practices. By delving into the intricate dynamics of ecosystem preservation and green growth, this paper illustrates pathways toward a future where economic progress harmonizes with ecological integrity.

This paper is divided into five sections, beginning with Section 1: Introduction, delineating the current environment status and the linkage to green growth. It will also outline the challenges in green growth practices and international organizations as an effective solution. *Sections 2 and 3* will provide practical examples of green growth programs carried out by the Korean Green Growth Trust Fund (KGGTF). Following *Section 3, Section 4: Contribution to Sustainable Development* will examine the contributions of KGGTF grant programs to sustainable development. Finally, *Section 5: Conclusion* will discuss pending issues and future directions.

1.1. Global Trends in the Environment Sector

The environmental sector plays a crucial role not only in influencing climate change but also in perpetuating a vicious cycle of pollution. As depicted in FIGURE 1, air, water, and soil pollution are interconnected, leading to deteriorating environmental conditions. Waste disposed of in soil not only exacerbates soil quality but also contaminates water sources as it seeps into freshwater.[1] Contaminated water decays the sea ecosystem and triggers health problems and poverty issues, especially in underdeveloped regions where the economy heavily relies on sea or groundwater.[2] Moreover, these wastes generate Greenhouse Gas (GHG) emissions, causing climate change and deterioration of soil again. Furthermore, human activities that exploit nature sometimes lead to deforestation, exacerbating the situation. Regardless of the initial cause, polluted environments exacerbate themselves, resulting in consequences such as acid rain, elevated carbon dioxide levels, ozone layer depletion, climate change, global warming, and species extinction.[2]

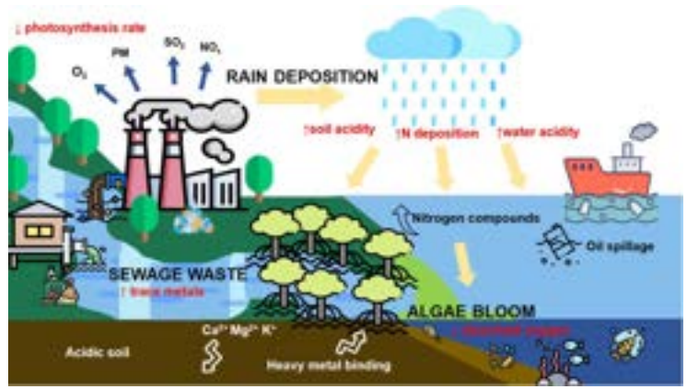

FIGURE 1. CORRELATION OF ENVIRONMENTAL POLLUTION IN AIR, WATER AND SOIL TO THE ECOSYSTEM[1]

The problem is that the current environmental status is particularly alarming, characterized by cumulated environmental degradation and climate change. Environmental degradation is not only a problem of nature; it also eradicates economic growth and social inequality. Preserving nature and implementing sustainable management practices are vital for maintaining a healthy environment and promoting well-being for all.

Major contributors to recent environmental degradation include forest degradation and the accumulation of solid waste and sewage. To begin with, forest degradation is a significant cause of environmental pollution. Forests act as carbon sinks, absorbing a net 7.6 billion metric tons of carbon.[3] However, unlike the Amazon and Congo River Basin, which are depicted as green in FIGURE 2, the southeast Asia region, comprising the Indochina peninsula, Indonesia, and the Lao People's Democratic Republic (PDR), recently emitted greenhouse gases rather than absorbing them. As demonstrated in FIGURE 2, this region emitted 1.6 billion metric tons of carbon while only absorbing 1.1 billion metric tons, resulting in 0.49 billion metric tons of carbon emissions due to the deforestation and drainage of peat soils. To make matters worse, these statistics may be underestimated because the deforestation status of Lao PDR, Myanmar, and East Sumatra may not be reliably recorded.[4] The fact that forest degradation not only negatively impacts water, air, and soil individually but also infuriates each other underscores the importance of strategies for restoring forestry areas.

FIGURE 2. SOUTHEAST ASIA RESULTING IN CARBON EMISSION[3]

The reasons for forest degradation vary depending on the context, but agriculture is consistently identified as one of the main factors. The increased demand for subsistence agriculture has been responsible for most of the world's deforestation, as it creates incentives to convert forests into farmland and ranch areas.[5] This trend has been fastened due to the expansion of commercial agriculture and the increased usage of nitrogen fertilizers. Indeed, the constant rise in the usage of nitrogen fertilizer has nitrated surface and groundwater, which, in turn, causes health issues, especially in developing nations where people heavily rely on groundwater.[6] Additionally, forests are heavily exploited for natural resources, including timber production and mining activities. Illegal large-scale logging, often driven by international timber markets, has further contributed to deforestation.[4,7] Given that the world's largest biodiversity is located in developing countries where they heavily rely on exports of natural resources, it is crucial to find effective management methods to preserve the ecosystem while securing economic growth.[8]

It is noteworthy that degradation in the environment, including forestry, is often related to solid waste problems. Improper waste disposal practices, including illegal dumping and inadequate waste management infrastructure, can contribute to the degradation of ecosystems. Meanwhile, particular focus should be given to the solid waste problem as the accumulation of solid waste is not only a reason for deforestation but also another major reason for the vicious cycle of pollution. For example, plastics and other non-biodegradable materials can leach harmful chemicals into the soil and water, contaminate natural habitats, and, in turn, affect the ground ecosystem, as demonstrated above. Moreover, solid waste accumulation can alter ecosystem dynamics by disrupting nutrient cycles, altering soil composition, and hindering natural regeneration processes.

Then, how severe is the solid waste problem globally? According to the World Bank, the world generates approximately 2.01 billion tons of municipal solid waste annually, with at least 33% of that not managed in an environmentally safe manner.9 The global waste is projected to grow to 3.40 billion tons by 2050, surpassing population growth during the same period. This growth is not uniform across all regions. For instance, the East Asia and Pacific region generates the majority of the world's waste (23%), and South Asia is growing fastest.[9]

Despite the massive increment, it is crucial to emphasize that these wastes are not disposed of in an appropriate way. FIGURE 3 demonstrates how wastes are disposed of.[9] Unlike our wish, approximately 37% of waste is currently dumped or disposed of in some form of a landfill, with only 3.7% of the waste dumped in a controlled manner. Open dumping accounts for about 33% of waste, while 19% are recovered through recycling and composting. Disparities in waste disposal practices exist among countries, with adequate waste disposal or treatment being predominantly seen in high- and upper-middle-income countries. In contrast, lower-income countries generally rely on open dumping, with 93% of waste being dumped in this manner due to its cost-effectiveness.[9,10] Due to rapid urbanization and inadequate infrastructure for waste management, these countries often resort to unsustainable waste disposal practices such as open dumping and burning.[11] This phenomenon again results in environmental pollution, ecosystem degradation, and public health hazards. Despite efforts to promote recycling and composting, the proportion of recycled waste remains relatively low globally, highlighting the need for enhanced waste management strategies and infrastructure investment.

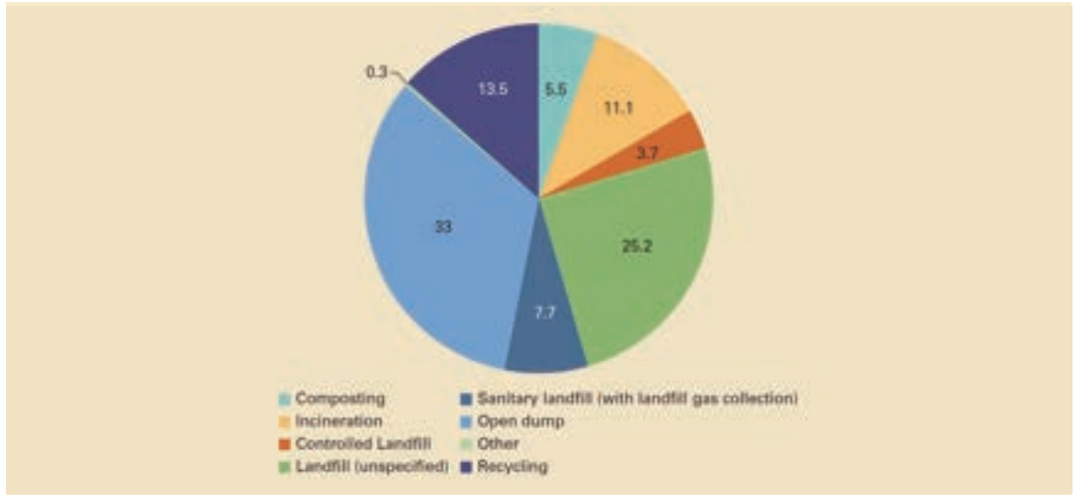

FIGURE 3. GLOBAL TREATMENT OF DISPOSAL OF WASTE (PERCENTAGE)[9]

1.2. Green Growth as a Key Solution

Recognizing the critical issue of environmental degradation, merely proposing regulations alone cannot suffice as a solution. Economic empowerment remains a crucial task to any economy – especially in developing nations, where these regulations may hinder short-term economic gains. However, it is irrefutable that indiscriminate exploitation of the environment is a result of market and institutional failures, jeopardizing long-term resilience. The key is that the environment is not just a luxury; environmental sustainability is a necessary condition for economic growth. As a result, the concept of green growth has emerged as a holistic approach that incorporates the trade-off between economic prosperity and environment preservation.

Green growth recognizes the inseparable link between environmental sustainability and economic growth, as natural capital significantly influences overall economic development. The left graph in FIGURE 4 illustrates the existence of a threshold, indicating that when the depletion of natural resources surpasses a certain point, economic growth declines.[12] Conversely, the right graph depicts a positive correlation between the restoration of natural resources and economic growth.

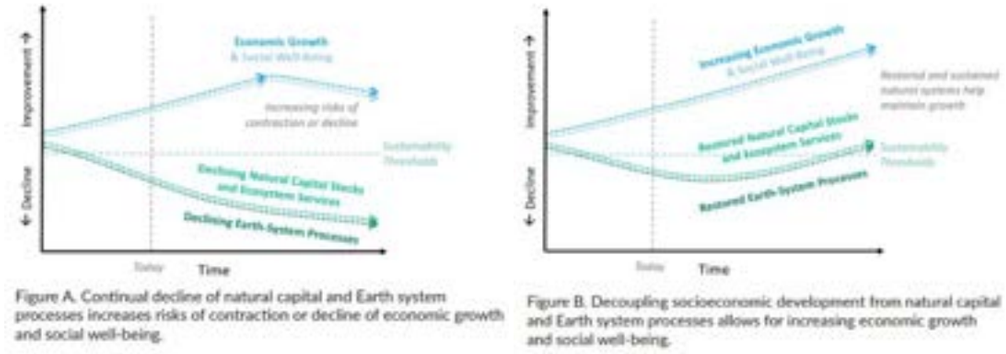

Figure A. Continual decline of natural capital and Earth system processes increases risks of contraction or decline of economic growth and social well-being.

Figure B. Decoupling socioeconomic development from natural capital and Earth system processes allows for increasing economic growth and social well-being.

FIGURE 4. ENVIRONMENT AND ECONOMIC GROWTH[12]

Furthermore, academic literature suggests that economic growth and social welfare cannot be separated from the environment. "The loss of welfare of the population in developing countries today as a result of inadequate access to safe drinking water and sanitation, or of urban air pollution".[13] The social cost of contamination is proportional to economic growth, while the gain is distributed only to the top 10% of the population.[14]

The importance of the environment in socioeconomic gains is also stressed in the business sector. For instance, climate change may result in an inefficient supply chain and systemic risk in the financial market.[15] Indeed, the McKinsey report also points out that the environmental risk can also generate infrastructure asset damage while hurting the poorest communities and populations but not the developed.[15] The consensus about the importance of the environment was reached by all members of the civic society, as well as the academic and business community. This underscores the critical need to prioritize sustainable practices to ensure long-term economic prosperity.

In the pursuit of green growth, practical practices encompass a wide range of initiatives aimed at promoting sustainability while fostering economic prosperity. Examples include the promotion of eco-tourism, which not only generates income for local communities but also raises awareness about the importance of biodiversity conservation and environmental stewardship. Additionally, subsidizing the use of eco-friendly resources incentivizes businesses and individuals to adopt more environmentally responsible behaviors. Effective solid waste management strategies, including recycling programs and waste-to-energy initiatives, help minimize pollution and ecosystem degradation while creating new economic opportunities in the green economy.

Despite the potential benefits of green growth practices, achieving these objectives is not without challenges. Green growth is a relatively new and perplexing concept and should precisely be planned and executed. Therefore, practitioners of respective government agencies often demand successful cases and appropriate networks that they can reference. "They want to be connected and have ready access to practical knowledge and proven results."[16] Even if the administrators possess adequate information, this information is context-dependent. Another challenge is that sometimes, there is no reliable administrative data to delve into particular contexts. Even if it exists, public administration data is sometimes imprecise, incomplete, or has variations.[17] Lastly, some environmental problems require international collaboration as their impact is not limited to a single country. These challenges all contribute to limited capacity building for green growth initiatives.

International organizations can play a vital role in streamlining international collaboration by bringing countries with shared objectives. Given the interconnected nature of environmental issues and their global impact, knowledge exchange opportunities, increment of successful practices around the world, and data collection can all contribute to building capacity. The most notable organization in this regard is the KGGTF, which stands out as the only trust fund within the World Bank dedicated solely to the promotion of green growth initiatives.[18] Upon the government of the Republic of Korea incorporating green growth into its national development strategy in 2008 for the first time in the world, the KGGTF was established in 2011 to assist client countries financially and share knowledge about green growth. As they functioned for more than ten years, assisting 180 green growth programs in client countries, a deeper exploration of KGGTF grant cases is vital to understand how green growth initiatives are developed and how they affect stakeholders and accomplish a sustainable economy.

In particular, two grants will be presented from Section 2 to Section 3. The first case consists of a comprehensive green growth policy program in Lao PDR. This grant is highlighted for two reasons. Firstly, it offers a comprehensive package that includes environmental analyzes and the promotion of knowledge sharing to tackle the vicious cycle. Secondly, the program provides concrete programmatic advice for forest management in areas facing severe degradation. Notably, these forests are among the world's largest contributors to greenhouse gas (GHG) emissions, as mentioned in Section 1.1. The second case is a solid waste management program held in the mountainous regions of the Himalayas. This program was also selected for two reasons. To begin with, it involves three distinctive countries, making the role of international organizations relatively more crucial. Furthermore, the spread of the consultation region resulted in challenges in collecting data, making it essential to establish a shared understanding among client countries.

2. GRANT CASE STUDY 1: GREEN GROWTH POLICY PROGRAM IN LAO PDR

2.1. Background

2.1.1. Severity of Environmental Degradation

Lao PDR has achieved rapid growth and poverty reduction since 2000. Gross Domestic Product (GDP) has grown at an average annual rate of 8 percent since the beginning of the century. Rapid economic development was associated with a fall in the national poverty line, from 34 percent in March 2002 to 23 percent in December 2012. However, while these activities provided important economic gains, they have also resulted in significantly high rates of natural resource depletion and environmental degradation.

The unsustainable exploitation of natural resources in Lao PDR is highlighted in FIGURE 5, titled 'Natural Resources Depletion.' This figure indicates that Lao PDR incurred an average annual loss of 7.4 percent of its natural resources, contributing to its economic growth over 15 years. This rate is also markedly higher compared to Thailand (1.8%) and Vietnam (3.67%).

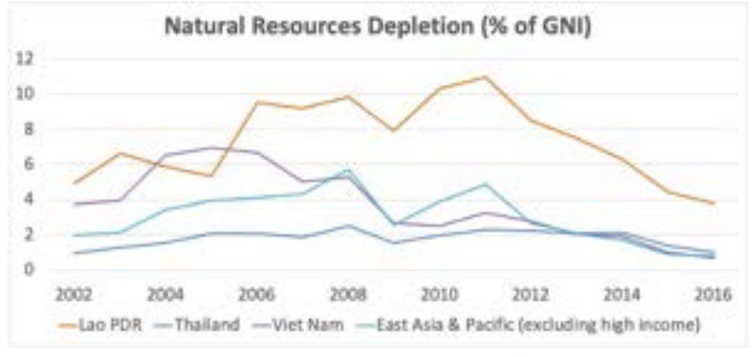

FIGURE 5. NATURAL RESOURCES DEPLETION (% OF GNI)[19] (created by the author)

Similarly, as illustrated in FIGURE 6, the average total natural resources rents for Lao PDR were recorded at 9.8% over 15 years, which is substantially higher than those of neighboring countries such as Thailand (2.57%) and Cambodia (2.48%). This indicates the Lao PDR economy's significant reliance on natural capital.

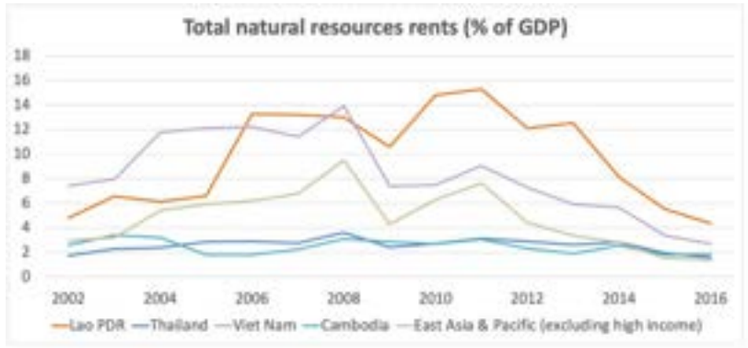

FIGURE 6. TOTAL NATURAL RESOURCES RENTS (% OF GDP).[19] (created by the author)

Furthermore, as depicted in FIGURE 7 below, the most significant environmental degradation in Lao PDR is linked to environmental health, incurring an annual cost equivalent to 14.6 percent of GDP. The most substantial costs are associated with household air pollution. Other significant challenges include inadequate water supply, sanitation, hygiene, outdoor urban air pollution, and lead exposure. Additionally, FIGURE 8 illustrates that as the country undergoes modernization and promotes economic development, environmental degradation has led to quantifiable economic damages amounting to US$766 million annually, which accounts for 4.8 percent of GDP. In sum, Lao PDR's annual cost of environmental degradation (reduced natural capital from depletion and reduced human capital from pollution) is estimated at 19.4 percent of GDP in 2017.

	Cost (Cost of Morality + Morbidity / billion LAK)	Cost (% equivalent of GDP)
Household Air Pollution	8,010	5.68%
Ambient Air Pollution	4,933	3.50%
Water, Sanitation and Hygiene	4,076	2.89%
Micro biological Pollution	3,698	2.62%
Arsenic in groundwater	379	0.27%
Lead (Pb) Exposure	3,558	2.52%
Lead (Pb) Exposure - children	2,635	1.87%
Lead (Pb) Exposure - adults	923	0.65%
Total	**20,577**	**14.60%**

	Cost (US million)	Cost (% equivalent of GDP)
Cost of Deforestation	275	1.70%
Cost of Forest Degradation	189	1.20%
Cost of Natural Disasters	165	1.00%
Soil Degradation Cost	101	0.60%
Cost of Fish habitat destruction	36	0.20%
Cost of exposure to mercury	0.8	0.01%
Total	**766**	**4.80%**

FIGURE 7. 2017 ESTIMATED ANNUAL COST OF ENVIRONMENTAL HEALTH EFFECTS IN LAO PDR[21]
FIGURE 8. 2017 ESTIMATED ANNUAL COSTS OF ENVIRONMENTAL DEGRADATION IN LAO PDR[21]
(created by the author)

These figures, as well as the status of natural resource depletion and environmental degradation, have severe implications. The economic burdens of such environmental challenges tend to disproportionately impact economically disadvantaged and other vulnerable populations, thereby constraining the efficacy of economic growth in alleviating poverty.[20] Furthermore, environmental stress undermines the ability of natural resources to sustain livelihoods and provide resilience against natural disasters like floods. This issue is particularly acute in Lao PDR, where over 70 percent of the population depends on forests, soil, wetlands, and fisheries for their income and nutrition. Many vulnerable populations reside in areas where forests are degrading or vanishing. These communities are also more likely to depend on biomass fuels such as wood and charcoal for cooking, and they often have restricted access to safe drinking water and adequate sanitation facilities. Additionally, they are more frequently situated near contaminated land, polluted surface waters, and flood-prone regions.

To tackle this environmental degradation challenge, the Lao PDR has shown a commitment to transition toward a green growth vision as articulated in the 8th National Socio-Economic Development Plan (NSEDP; 2016-2020) and the National Green Growth Strategy (NGGS) for 2030. To booster the Government of Lao's (GoL) movement and endeavor, World Bank aims to enhance GoL's legal, policy, and organizational framework and inform evidence-based policy making in the transition to green growth, through the program 'Green Growth Platform for Lao PDR.'

2.1.2. Lack of Sufficient Budget and Robust Policy and Framework

The Government of Lao was willing to address the problem of environmental degradation as aforementioned. However, primary issues were the insufficient budget and exiguous institutional structure including policy and frameworks.

The budget allocations for environmental protection in Lao PDR are insufficient to address severe pollution problems. According to the World Bank, the Natural Resources and Environment Sector Plan 2011–2015 had a total budget of US$199.6 million, including the GoL development budget.[21] The amount allocated to environmental programs during this period represented 10 percent of the plan's budget. However, it accounted for less than 1 percent of the development budget provided by the GoL to the plan, and, as a result, the environmental protection program was highly dependent on donor support. Furthermore, the Ministry of Natural Resources and Environment (MoNRE) of Lao PDR reported that the requested budget for the implementation of the 2016–2020 Natural Resources and Environment Sector Plan was LAK 4,595 billion, while the actual budget was LAK 2,553 billion. At the time of the plan's preparation, MoNRE faced a financing gap of LAK 2,042 billion, or approximately 45 percent of the resources needed for the plan's implementation.

Moreover, Lao PDR lacked a meticulous and well-structured framework or strategy, spanning from the assessment tool itself to detailed policies for various environmental sectors. Lao PDR's Environmental Impact Assessment (EIA) process faced issues, including inadequate screening, poor quality of reports, and a general lack of monitoring of program compliance with the EIA's approval conditions. Lao PDR did not have a priority-setting mechanism, and industrial facilities were not subjected to requirements for self-monitoring and reporting their pollution discharges. Regarding the forestry sector, there was no specific enabling policy or strategy in place for Public-Private-People Partnerships (PPPP), nor a strong supporting regulatory framework. Concretely, according to the World Bank, there were no regulations or guidelines on forest management for smallholder plantations, and even the minimum legal requirements for plantation registration were unattainable for most individuals and households.[22] Additionally, the policy, legal, and regulatory frameworks related to production forestry were complex, inconsistent, unclear, and not consistently interpreted. Furthermore, in terms of pollution, Lao PDR faced air pollution caused by cookstoves and soil degradation due to pesticides. However, policy development for addressing cookstove issues was insufficient, and there was a need for Lao PDR to create a clear framework of reference and action for all actors: coordinated institutional mandates, robust enforcement, training, compliance mechanisms, and clear and feasible rules for pesticide dealers and users.

Considering these collective reasons, Lao PDR required international aid to enhance the overall policy and framework. To effectively manage its environmental challenges, the nation needed not only financial support but also technical expertise and strategic guidance to develop and implement coherent and sustainable environmental policies.

2.2. Summary: Programmatic Advisory Services and Analytics (PASA)

The grant program 'Green Growth Platform for Lao PDR' was held for four years since 2016, with $900 thousand budget. This program aims to foster a comprehensive approach to making informed, strategic, and cohesive policy decisions, developing a robust green growth platform in Lao DPR. As Advisory Services & Analytics (ASA) program, it aims to bring together diverse stakeholders for knowledge exchange, build a consensus for a unified policy vision, synthesize the knowledge gained into actionable insights, and develop strategic frameworks and recommendations to guide effective policy actions.

The program is organized in two pillars. Firstly, Pillar 1, 'Support to the Development of a National Green Growth Policy Platform', is aimed directly at decision-makers and government agencies. Its objective is to foster comprehensive and informed dialogue on Green Growth technicalities and policy making, guarantee high-

quality consultations among key stakeholders, provide specialized advisory services, and disseminate knowledge regarding Green Growth strategies and reforms tailored to Lao PDR's unique context. The primary audience includes the Ministry of Planning and Investment (MPI) and other ministerial bodies leading the government's Green Growth policy program, which may involve consultation and coordination with non-governmental stakeholders

FIGURE 9. STRUCTURE OF 'GREEN GROWTH PLATFORM FOR LAO PDR'.[22] (created by the author)

when appropriate. The Pillar encompasses a series of deliverables that contribute directly to the formulation, advancement, and preparedness of policy actions delineated within the framework of the government's Green Growth policy program. These deliverables are categorized into three components: (i) Policy Strategic Environmental Assessments (PSEAs) and Policy Social Impact Analyses (PSIAs), (ii) Knowledge Exchange and Consultations, and (iii) Technical Input for Green Growth Mainstreaming.

Concretely, PSEAs and PSIAs were conducted to evaluate the operations related to the country's transition to Green Growth. These assessments were instrumental in informing the Green Growth Development Policy Operation (DPO) about prior actions concerning Environmental Impact Assessment regulations and compliance monitoring. Furthermore, the 'Knowledge Exchange and Consultation' component comprised technical-level knowledge sharing, advisory services, consultations, and high-level government policy dialogues and learning events. Activities included sector-specific workshops, consultation sessions on draft regulations, and high-level forum to review and report on policy progress and convergence in green growth. Moreover, 'Technical Input for Green Growth Mainstreaming' consisted of developing policy notes, providing technical input, drafting regulations, and offering just-in-time advisory support. This covered areas such as Green Growth financing, disaster and climate risk mitigation in public investment program reviews, and pesticide management, yielding over eight policy notes on distinct topics.

Pillar 2, 'In-depth Analytical and Technical Assistance on Selected Priority Green Growth Areas', encompasses three sub-tasks, each involving thorough engagement. These are: (i) 'Sustainability in Lao PDR's forests', exploring pathways to scale up forestry certification schemes and address forest degradation; (ii) 'Developing Nature-Based Tourism', assessing the potential of nature-based tourism as a contributor to Green Growth in Lao PDR; and (iii) 'Lao PDR State of Environment 2019', examining the status of air, water, and soil pollution through a State of the Environment Update.

Specifically, the ASA on Sustainability in Lao PDR's forests aims to contribute to the national green growth strategy by analyzing requirements and developing a roadmap for promoting certified Sustainable Forest Management (SFM) and forest restoration in Lao PDR's production forest areas. The ASA on forestry includes several sub-studies, conducted in collaboration with the Lao PDR Ministry of Agriculture and Forestry and the Department of Forestry. These studies focus on: (i) sustainable forest management; (ii) markets for certified wood; (iii) policy support for SFM, chain-of-custody certification, and timber legality assurance systems; (iv) public-private partnerships for forest

restoration; (v) the economics of certified SFM in Laos; and (vi) a retrospective analysis of factors influencing forest sector reform over the past decade. This ASA aligns with the 'Programmatic Green Growth Development Policy Financing,' which bolsters the government's policy reforms to expand certified sustainable forest management and establish a timber legality assurance system.

Regarding ASA on 'Developing Nature-Based Tourism', the ASA assesses the demand profile for Lao nature tourism offerings, on the one hand, and identifies key institutional and regulatory issues that constrain the access of private sector-led tourism development to Lao PDR's national protected areas and other natural areas in response to this demand. It also makes recommendations on how to ensure that nature-based tourism itself does not cause damage to the environment and how it can best contribute to poverty reduction among communities living in and around protected areas, and what institutional arrangements would be most conducive to these goals, learning from the experiences from select countries with similar conditions. Moreover, the ASA on 'Lao PDR State of Environment 2019' is to provide the analytical basis to support the GoL in designing and implementing environmental policy and institutional reforms aimed at addressing Lao PDR's environmental and pollution management priorities for poverty alleviation and shared prosperity. The activity consists of analysis of the cost of environmental degradation, institutional analysis, and recommendations to address environmental priorities.

2.3. Stakeholder Roles and Involvement

As the 'Green Growth Platform for Lao PDR' program aims to reform and enhance the policies by providing strategic analyses, having knowledge sharing, high-level dialogue, and workshops, the related stakeholders span from the ministries to the communities, including various associates, federations, NGOs, and research institutions as well.

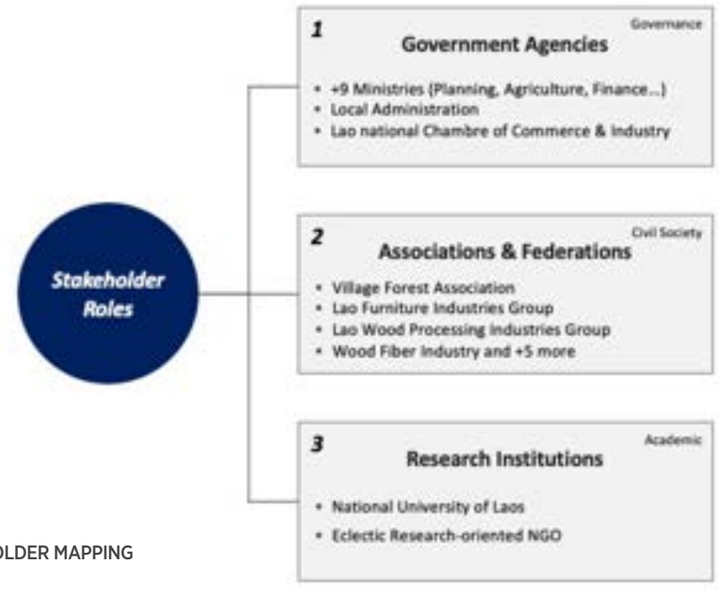

FIGURE 10. CASE 1: STAKEHOLDER MAPPING

First and foremost, the ministries are pivotal in this endeavor, spearheading the nation's transition toward green growth. Their main role involves revising, developing, and implementing innovative policies, systems, and frameworks, all of which are supported by robust inter-ministerial cooperation. This collaborative approach is exemplified in the policy development process. For example, the 'Clean Healthier Green Growth Cooking' policy note demonstrates how the Government of Laos (GoL) established a high-level inter-ministerial task force. Chaired by the Ministry of Energy and Mines (MEM) and involving seven other ministries, this task force exemplifies the cooperative effort required to enact substantial change. Moreover, the ministries are responsible for issuing

directives to sectoral agencies, incorporating green growth principles into legal statutes with detailed procedures, methods, timelines, and coordination protocols. They also develop and oversee the legal framework that guides all government entities, including local authorities and state enterprises, as well as individual and organizational stakeholders. This ensures the comprehensive integration of green growth objectives across all levels of government operations.

Second, associations and federations are integral to the advancement of the Green Growth Platform, as they broadcast overarching policies and enhance the development of standards and guidelines for targeted market sectors. They harness their collective expertise to assemble essential data, including statistics, case studies, best practices, and guidelines, which are critical in shaping informed policies and procedures. To showcase their role in the action, for example, the 'Forestry Synthesis Report' produced by the ASA on 'Sustainability in Lao PDR's Forests' detailed the contributions of five associations: the Village Forest Associations (VFA), the Lao Furniture Industries Group, the Lao Wood Processing Industry Association, the Luang Prabang Teak Plantation Association, and the Wood Fiber Industry Association. Furthermore, regarding the policy note on 'Clean Healthier GG Cooking', it suggests that encompassing the Lao Women Business Association (LWBA) and agriculture, forestry, and health extension specialists could strengthen and accelerate program implementation. These bodies may mandate that their members and stakeholders adhere to standards of legality and sustainability, while member companies and related associations may join to align with codes of conduct or ethics. This compliance is not only about fulfilling legal obligations but also about affirming corporate social responsibility, enhancing supply chain efficiencies, and highlighting the benefits of greener procurement and sustainable policies.

Lastly, research institutions such as the National University of Laos and various NGOs are pivotal stakeholders in research activities and in providing practical insights. Furthermore, the 'Forestry Synthesis Report' by the ASA, which examined sustainability in Lao PDR's forests, emphasizes the importance of involving local communities in developing a solid policy implementation framework. Their on-the-ground experience is invaluable for identifying challenges and offering perspectives that help to establish precise criteria for green growth initiatives.

2.4. Highlights and Limitations

The 'Green Growth Platform for Lao PDR' program, which aims to reform and enhance policies across various sectors, has advanced not only the conservation of natural capital—such as forests, biodiversity, and soil—but also the refinement of economic frameworks, including environmental taxation. In developing the Green Growth Platform in Lao PDR, 52 documents were prepared, including eight policy notes, and 3 workshops were conducted for high-level dialogue and knowledge sharing. Furthermore, comprehensive diagnostics of environmental factors have been conducted, tackling critical issues like household and ambient air pollution, solid waste and plastic management, poverty indicators, and natural disasters. These diagnostics offer evidence-based insights crucial for guiding the prioritization and implementation of policy reforms.

However, the documentation from the 'Green Growth Platform for Lao PDR' program reveals two limitations. Firstly, there is a notable lack of participation by local communities and associations in the dialogue and decision-making processes, despite a majority of the 52 documents emphasizing the critical need for such involvement in green growth development. Opportunities for locals to contribute to policy formulation needed to be more marked, raising concerns about the resulting policies' representativeness and effectiveness. Secondly, the prevalent use of the 'economic valuation method' in diagnostic papers—while useful for quantifying the monetary value of environmental goods for cost-benefit analyses—may inadvertently neglect the multifaceted nature of green growth. This approach often fails to account for natural resources' social and cultural significance and the varied impacts of environmental changes on different communities. An alternative, such as 'Multi-Criteria Decision Analysis (MCDA),' could allow for a more comprehensive evaluation by considering a wider array of quantifiable and non-quantifiable factors. Moreover, implementing 'Participatory Valuation Methods' could directly engage local communities in the valuation process, tapping into their knowledge and valuing their perspectives on the importance of environmental assets. This could uncover communities' non-monetary significance on ecosystems and biodiversity, which is particularly relevant in Lao PDR where natural resources are closely linked to local livelihoods. By embracing these additional methods, the program could provide more comprehensive and inclusive policy recommendations that are attuned to the diverse needs and values of all stakeholders in Lao PDR's green growth journey.

3. GRANT CASE STUDY 2: SOLID WASTE MANAGEMENT IN THE HIMALAYAN MOUNTAINS

3.1. Background

3.1.1. Severity of Environmental Degradation

Mountains serve an essential role in supplying water, energy, food, and other services to millions of people living in the mountains and downstream. [23] Albeit, mountain areas are suffering from a growing solid waste management (SWM) problem with an increasing number of tourists and households living in the mountains. It is a common situation for middle- and lower-income countries to have problems with the SWM. However, mountain areas are much harder to manage well due to their unique characteristics. Lack of formal institutional systems, non-biodegradable waste, transportation difficulties, tourism-related waste, population growth and urbanization, mining-related waste, risk of waste crime, and impact on freshwater ecosystems are the common challenges that Mountain areas face.[24]

Aligning with those challenges, Himalayan Mountain areas are also multifaceted with SWM. Not only that, but Mountain areas in Asia also have poverty issues.[25] Compared to developed countries, having 37% of the world's mountain area and 9% of the world's mountain population, developing countries in Asia have 36% of the world's mountain area and 52% of the world's mountain population.[26]

With their unique geographical and financial context those are the factors that this program considered for the solutions: Topography and Geology, Remoteness of Settlements, Poor Institutional and Financial Capacity, Lack of Infrastructure and Road Networks, Impact of Tourism, Lack of Awareness and Adoption of SWM Practices, and Competing Priorities for Local Governments.

Based on this, the World Bank operated this program as part of Advisory Services and Analysis (ASA). This study recommends the solutions to Nepal, India, and Pakistan which are all countries facing the border lines to Himalayan Mountain areas. Not only does it provide the framework of solutions but also the good practices that other mountain areas can refer to.

3.1.2. Low Capacity & Meager Local Data

In addressing the challenges of SWM in mountain areas, capacity building, and data research emerge as vital strategies, as recommended by UNEP.[22] Especially with Capacity Building, empowering mountain communities and municipalities through capacity-building initiatives is fundamental for effective waste management. Integrated management plans should be developed, encompassing avoidance, recycling, minimization, treatment, and disposal. Tailoring solutions to local conditions, promoting local knowledge, and building awareness at all levels contribute to sustainable practices. Community-based initiatives, shared collection centers, and small-scale solutions adapted to remote mountain settings should be encouraged. Moreover, education campaigns within the mountaineering community and collaboration with global governing bodies can instill environmental values, fostering a sense of responsibility.

Despite the necessity of data in order to be sponsored by the government, meager local data exists in this region partially because it is separated into three distinctive countries. Besides, local data is also crucial to establish waste monitoring programs that enable baseline assessment and progress measurement. Scientific research should delve into the biophysical impacts of different waste streams on mountain environments and communities, fostering a deeper understanding of these complex relationships. An international research agenda should be pursued, integrating upstream and downstream scientific networks. This research should extend beyond urban waste, incorporating sectors like forestry and agriculture, to provide holistic insights. Applied and participatory research is essential to comprehend public attitudes toward waste and to incite behavioral change in challenging environments and diverse socioeconomic conditions.

In summary, prioritizing capacity-building efforts and fostering extensive data research are key pillars for sustainable waste management in mountainous regions. These strategies not only equip communities with the necessary skills but also deepen our understanding of the multifaceted challenges posed by waste in these unique environments.

3.2. Summary: Qualitative Waste Survey & Programmatic Advisory Services

To fulfill the goals of those two and provide good solutions, this program shared a dual-pronged approach, combining waste sampling and qualitative surveys. This comprehensive method allowed for a nuanced understanding of waste generation patterns and the socio-economic factors influencing waste management practices. Waste sampling was conducted across households from various income backgrounds and tourist establishments like hotels and restaurants.

The qualitative surveys encompassed diverse aspects, including socio-economic information, waste generation and management practices, environmental awareness, and willingness to engage in SWM efforts. The inclusion of both local residents and commercial establishments, such as hotels, provided a holistic perspective on waste management behaviors.

However, notable differences emerged, reflecting the unique contexts of each country. Geographical factors, cultural nuances, and regulatory frameworks influenced waste management practices. The studies were conducted in different regions, and the sampling sites varied. Additionally, the inclusion or exclusion of tourists in the qualitative surveys offered distinct insights into waste generation patterns in areas frequented by visitors.

Collaborators and partners also varied, with the Pakistan study conducted by Korean consultants and local partners. The study periods differed, impacting the observations of waste generation during specific times. Results revealed differences in waste composition, disposal practices, and management approaches among income groups, commercial establishments, and tourist areas.

Furthermore, the awareness levels of respondents regarding waste management issues and their willingness to pay for waste collection services demonstrated variations. Disposal practices, such as open dumping and waste disposal in nearby drains, varied among households in different regions.

The study acknowledged the limitations of a small sample size due to time constraints, cautioning against overgeneralization of the findings. Despite this constraint, the combined approach of waste sampling and qualitative surveys provided valuable insights into the complex dynamics of SWM in mountainous regions. The research underscored the multifaceted nature of the waste management challenge, encompassing environmental, social, and economic dimensions, and laid the groundwork for informed strategies tailored to the unique context of mountainous terrains.

The qualitative waste survey and programmatic advisory services provided a rich understanding of waste management practices and socio-economic factors influencing SWM efforts in the Himalayan Mountain region.

However, the diverse contexts of each country, including geographical, cultural, and regulatory differences, necessitated tailored solutions to address specific challenges. Therefore, this paper offers a range of recommended solutions that can be adapted to suit the unique characteristics of each area within the Himalayan Mountain region.

The Himalayan Mountain region poses unique challenges for SWM due to its geographical intricacies. Without giving specific solutions for each region, this paper provides multiple recommended solutions that each area can choose based on its characteristics.

In the realm of waste segregation and disposal, the paper advocates for the encouragement and incentivization of biomethanation programs at both household and community levels. This includes promoting the utilization of biomethane for cooking, a sustainable alternative to conventional fuels. Additionally, the proposition supports subsidies for alternative cooking fuels like kerosene or liquefied natural gas (LNG) at the source level. To further enhance waste disposal practices, the systematic segregation of biodegradable waste for composting is emphasized, with subsidies provided for home composting techniques. The enforcement of policies to phase out chemical fertilizers in favor of local compost is recommended, accompanied by initiatives to raise awareness and provide training on home composting techniques. Furthermore, the development of marketing strategies for compost, community engagement, and the establishment of guidelines for waste generated in adventure tourism are integral components of the proposed solutions.

Addressing the comprehensive domain of waste collection, transfer, storage, processing, and transport, the paper outlines strategies to improve existing waste collection systems, extend coverage, and integrate the informal sector into collection and segregation activities. Suggestions also include upgrading waste collection bins, establishing storage sites, and initiating sorting and mini-transfer stations to involve local inhabitants and create livelihood opportunities. Innovations such as waste processing and upcycling, in collaboration with cottage industries, are proposed to convert waste into valuable products, fostering economic opportunities. Furthermore, the paper advocates for efficient waste transportation systems designed based on waste characteristics, considering various transport options, including non-motorized modes and pack animals.

In the domain of waste treatment and disposal, the paper underscores the importance of reviewing technologies, identifying compost markets, and implementing large-scale composting. The phased-out use of synthetic fertilizers and the promotion of organic farming through locally made compost are integral to sustainable waste treatment. Efforts to identify and close illegal dumping sites, along with a steadfast commitment to avoiding landfills in mountain areas, are cornerstones of the recommendations. Finally, the paper concludes with a menu of options for collection and treatment, highlighting the need for a multi-stakeholder approach, community engagement, local technology emphasis, regulatory measures, and the promotion of a waste-to-wealth philosophy as key components of a sustainable SWM strategy in the Himalayan Mountain areas.

3.3. Stakeholder Roles and Involvement

In India, the solid waste management (SWM) landscape involves a multitude of stakeholders, including the government, private sector, NGOs, and informal sectors. The government, both at the central and local levels, plays a crucial role in providing direct waste management services, encompassing collection, sorting, transportation, recycling/recovery, and disposal. However, recycling is mainly handled by the informal and private sectors, with NGOs promoting recycling through awareness campaigns. The private sector is actively engaged in different aspects of the SWM chain across various cities, ranging from collection and segregation to transportation, treatment, and disposal. Despite a robust legal framework, challenges persist in comprehensive implementation, leading to the informal sector often stepping in to address gaps and incentivizing private agencies to participate in waste management activities.

Nepal's SWM framework emphasizes the responsibility of urban and rural municipalities in waste management, with federal ministries overseeing technical, operational, and financial aspects. Local governments, empowered by

the 2015 Constitution, collaborate with ministries, departments, and agencies like MoFAGA, DoE, DWSS, DUDBC, DoHS, and AEPC to manage MSW, fecal sludge, and wastewater. The Department of Tourism (DoT) takes charge of waste from mountaineering expeditions and trekking. Local governments finance SWM from their budgets, supplemented by grants from the federal government and support from international development partners like the World Bank, ADB, and JICA. The Bank's engagement includes a results-based financing program, indicating a collaborative approach to address funding gaps and enhance waste collection services.

In Pakistan, the SWM sector involves various stakeholders, including the government, the private sector, and international organizations. Government bodies like the Ministry of Climate Change and the provincial Environmental Protection Agencies (EPAs) are responsible for regulatory oversight and policy development. The private sector actively participates in waste management activities, including programs supported by international funding. The World Bank, for example, has funded projects like the Lahore composting facility. Additionally, market development and the sale of emission reduction credits under the Kyoto Protocol demonstrate innovative financing mechanisms. While challenges persist, the collaboration between public and private sectors, along with international support, reflects a multifaceted approach to address waste management issues in Pakistan.

In summary, India relies on a blend of public and private sector involvement, including a significant role for the informal sector. Nepal prioritizes municipal responsibility, with support from federal ministries and international partners like the World Bank. Meanwhile, Pakistan showcases collaboration between government bodies, the private sector, and global organizations, emphasizing innovative financing. Despite varying approaches, all three countries share common challenges, such as the need for effective regulation, ample financing, and sustainable solutions for the growing solid waste issues. The engagement of diverse stakeholders underscores the collective effort required for sustainable and efficient solid waste management in South Asia.

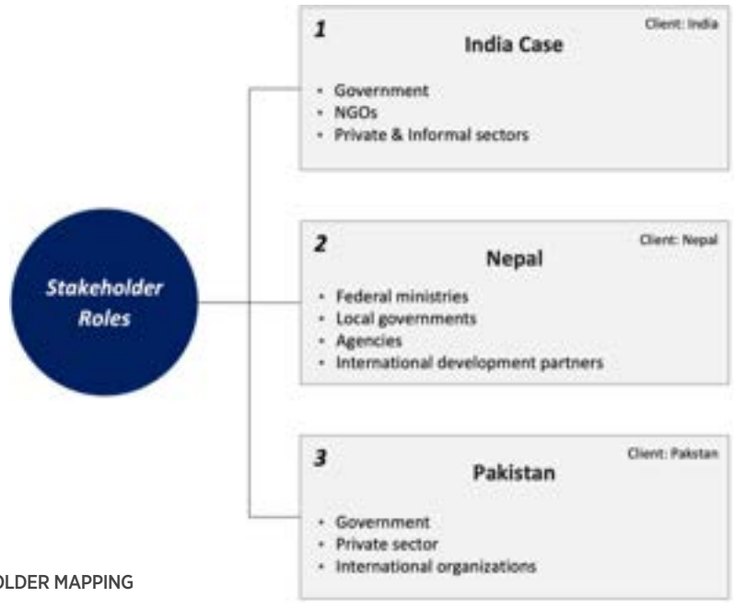

FIGURE 11. CASE 2: STAKEHOLDER MAPPING

3.4. Highlights and Limitations

The grant program for solid waste management (SWM) in the Himalayan Mountain areas exhibits commendable strengths, notably through its multilevel engagement strategy. By involving local, provincial, and federal authorities in India, Nepal, and Pakistan, the program aligns with the decentralized governance structures of these nations. The collaboration with international entities, particularly the World Bank and the Korea Green Growth Trust Fund, reflects a commitment to leveraging global expertise and resources, indicative of a comprehensive and interconnected approach to SWM challenges.

The inclusion of diverse financing mechanisms is a notable highlight, showcasing the program's innovative approach. By incorporating traditional loans, results-based financing, and private sector engagement, the initiative strategically addresses resource mobilization challenges. Furthermore, the emphasis on knowledge sharing, including the establishment of networks for learning from similar communities and leveraging policy think-tanks, underscores a commitment to continuous improvement and coordination in addressing SWM complexities.

However, the program is not without its limitations. Without an evaluation report, it is challenging to gauge the actions taken and the impact made following the grant program. Moreover, the good practices report, while categorizing the sector into four divisions and providing examples, lacks an ultimate standard for defining good practices or the rationale behind their classification. This absence of clarity might hinder effective replication.

Additionally, garnering attention from developing countries with low population density, particularly those grappling with SWM issues, poses a challenge. Given the poverty prevalent in such regions, presenting data and specific solutions with financing from entities like the World Bank (WB) could significantly enhance understanding and implementation capabilities.

In conclusion, although the grant program demonstrates commendable strengths in its multilevel engagement, innovative financing, and emphasis on knowledge sharing, it is essential to recognize and address the identified limitations. Achieving sustainable solutions necessitates a proactive approach to financial constraints, robust regulatory enforcement, and the strategic integration of the informal sector. Moreover, the establishment of effective data collection systems is imperative for informed decision-making and the overall success of SWM initiatives in the Himalayan Mountain areas.

4. CONTRIBUTION TO SUSTAINABLE DEVELOPMENT AND LIMITATIONS

4.1. Comparison of Contributions to SDGs

FIGURE 12. SUSTAINABLE DEVELOPMENT GOAL CONTRIBUTIONS

To measure the case program's contribution to SDGs, we categorized and assessed the SDGs into three different pillars: Environment, Social, and Economic Empowerment. When it comes to ***Case 1: Green Growth Policy Program in Lao PDR***, it contributed to the total 8 SDG goals. Under the Environment pillar, program Case 1 advanced SDGs 3, 13, and 15 by reducing health impacts from pollution, combating climate change through healthier cooking stoves, pesticide regulation, and sustainable forest management to preserve biodiversity. In the Social pillar, it aligned with SDGs 7, 11, and 17 by promoting sustainable energy solutions, enhancing rural sustainability, and fostering

policy coherence through multi-stakeholder partnerships. Lastly, under the Economic Empowerment pillar, Case 1 supported SDG 8 by creating jobs in nature-based tourism and sustainable forestry, contributing to the demand for responsibly sourced wood.

Similarly, ***Case 2: Solid Waste Management in Himalayan Mountain areas*** presents a robust initiative with significant implications for 7 SDGs goals. Under the Environment pillar, the program contributes to SDGs 6, 13, and 15. Effective solid waste management practices directly address issues such as water source contamination, greenhouse gas emissions, and the preservation of terrestrial ecosystems. Within the social pillar, the initiative enhances waste management infrastructure and practices, promoting the development of sustainable and resilient cities and fostering responsible communities in the Himalayan region, thereby aligning with SDGs 11, 12, and 17. Lastly, under the economic empowerment pillar, Case 2 contributes to SDG 8 by generating new employment opportunities and facilitating waste recycling initiatives.

Both ***Case 1: Green Growth Policy Program in Lao PDR*** and ***Case 2: Solid Waste Management in Himalayan Mountain areas*** significantly contribute to SDG 13: Climate Action. Case 1 addresses this goal through the introduction of healthier cooking stoves, pesticide regulation, and frameworks for sustainable forest management, all of which contribute to combating climate change and its impacts. Similarly, Case 2 advances SDG 13 by implementing effective solid waste management practices that reduce greenhouse gas emissions, thereby also mitigating climate change. While the approaches of the two cases differ—one focusing on policy change and the other on infrastructure and practice improvements—their shared implication is a strong commitment to environmental sustainability and climate action, demonstrating a concerted effort to meet global targets set by SDG 13.

4.2. Comparison of Limitations

	Environmental	Social	Economic
Grant 1	*- Reliable and rigorous inspections of environmental status should be guaranteed to ensure the continuous implementation of appropriate regulations and policies.* *- Thorough post-assessment is needed after implementing new cooking stove for replacing traditional cookstove*	*- Inclusive and holistic approach is needed to encompass diverse stakeholders in the development pathway.* *- Developing practical and successful field skills, as well as enhancing broader institutional capacity, will be challenging for Lao PDR.*	*- Appropriate fiscal instruments are necessary to support sustainable and rigorous program implementation.*
Grant 2	*- There is no definitive standard for defining good environmental and social practices within the program.*	*- Assessing the social impact of the program is challenging due to the absence of a follow-up report.*	*- Challenges associated with integrating informal waste pickers and recyclers into formal waste management systems may impede efforts to maximize economic benefits.*

FIGURE 13. LIMITATIONS BY SECTOR AND GRANT PROGRAMS

Aligning with the contributions, limitations are also categorized by three pillars: Environmental, Social, and Economic. In terms of environmental challenges, both programs face difficulties in establishing clear standards for defining and implementing good environmental practices. Grant 1 requires reliable and rigorous inspections to ensure the continuous implementation of environmental regulations and policies, while Grant 2 lacks a definitive standard for defining good environmental practices, hindering the establishment of clear guidelines. Socially, both programs encounter challenges in assessing their social impact and ensuring inclusivity. Grant 1 needs to adopt an inclusive and holistic approach to encompass diverse stakeholders effectively, while Grant 2 faces challenges in assessing social impact due to the absence of a follow-up report. Economically, both programs require appropriate fiscal instruments and financial mechanisms to support sustainable implementation. Grant 1 needs robust financial mechanisms to enhance broader institutional capacity, while Grant 2 encounters challenges in integrating informal waste pickers and recyclers into formal waste management systems, impacting economic benefits. These limitations are comprehensively picked out to ensure the success and sustainability of both grant programs.

5. CONCLUSION

This paper examined two representative environmental challenges: forestation and solid waste management. After describing the current status of these severe issues, the paper investigated how the concept of green growth mitigates the aforementioned challenges with two grant programs funded by the KGGTF. By informing programs in Lao PDR and the Himalaya Mountain area, the paper aimed to describe how green growth initiatives are effectively mitigating the environmental impacts and how these practices contribute to sustainable development and environmental practices.

This paper recognizes three limitations. To begin with, the presented cases are 'recommendations' made to client countries, and further policy evaluation was not accessible. Therefore, it is impossible to measure the effectiveness of the advisory service. Furthermore, we could not find cost-benefit analyses for our study, thus making it challenging to compare the effectiveness of potential policy practices. Most of all, it is acknowledged that two KGGTF cases are both context-dependent and may not be applicable to other areas facing environmental degradation.

However, by focusing on the regional context, this paper provides a clear focus on identifying and solving specific environmental challenges while securing economic growth. This targeted approach allows practitioners to comprehend the solutions recommended by the KGGTF within their respective backgrounds, recognizing that wide-ranging policies are required to address environmental solutions better suited to each region. From this point, readers can understand why green growth is an efficient solution for the environment, while it should be tailored to the unique circumstances.

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ANALYZING THE KGGTF URBAN AND TRANSPORTATION GRANT PROGRAMS



Chaeryun Lee Doyun Lee Woncheol Lee*

ABSTRACT

With 55% of the world's population living in cities by 2018, urbanization poses challenges like congestion and environmental degradation but also drives economic growth. The transport sector, expected to see a 50% increase in passenger traffic by 2030, faces sustainability issues, including reliance on fossil fuels and threats to public health. Green growth approaches like informal settlement upgrading and green mobility emerge to address these challenges and foster sustainability. In this paper, two grant programs — Green Mobility for Luang Prabang and Seam Reap and Metro Manila Citywide Slum Upgrading Program — in the urban and transportation sector by KGGTF will be analyzed regarding sustainability aspects and discussed future suggestions with the youth perspectives.

In Metro Manila, Philippines, a large-scale resettlement program was initiated in 2011 to relocate informal settler families from dangerous areas. However, challenges arose, prompting the KGGTF to launch a pilot Citywide Community Upgrading Strategy with various stakeholders. This program addressed obstacles to in-city housing, emphasizing community participation and stakeholder partnership. Similarly, Siem Reap, Cambodia, faced urban and transportation challenges, leading to the Green Mobility initiative. Siem Reap aimed to enhance sustainable transportation modes through multi-stakeholder collaboration, including electric public transport, cycling networks, and pedestrian infrastructure.

The evaluations of urban and transportation sectors in Metro Manila and Siem Reap programs highlight their contributions to sustainable development while recognizing limitations. The Metro Manila Citywide Strategy addresses informal settlements by fostering community-driven development and multi-stakeholder collaboration. Similarly, Siem Reap's Green Mobility initiative aims for sustainable urban development and transportation, focusing on environmental sustainability, economic growth, and social inclusivity.

Challenges include limited resident participation and the need for more explicit economic empowerment strategies. Recommendations for future programs emphasize enhanced community involvement, economic development plans, coordinated stakeholder engagement, and adaptability to local contexts. Both programs showcase innovative approaches to addressing urbanization challenges, underscoring the need for comprehensive and inclusive urban development strategies. Additionally, the youth perspective on green growth outlines five essential variables: Environmental Protection, Technology, Inclusivity, Resilience, and Economic Sustainability, suggesting a multifaceted approach to achieving sustainable development through green growth initiatives. These evaluations and recommendations provide insights into creating more resilient, inclusive, and sustainable urban environments globally.

* Chaeryun Lee is a graduate with a BA and Master's degree in urban planning from Arizona State University and Seoul National University, with 7+ years in community development and urban regeneration, pursuing her career path in global development cooperation.
* Doyun Lee holds a BA in Architecture and a Master's degree in Urban and Regional Planning, and is an incoming PhD student in Community and Regional Planning at University of Texas Austin.
* Woncheol Lee completed his bachelor's degree in Environment at McGill University and is currently majoring in Urban and Regional Planning at the Graduate School of Environmental Studies at Seoul National University.

1. INTRODUCTION

1.1. Urban Sector Trend: Urbanization

One of the most well-known trends in the urban sector is urbanization. According to the United Nations Economist Network, urbanization is one of the five global megatrends, along with climate change, demographic shifts, technological innovation, and inequalities.[1] About 55% of the world's population resided in urban areas by 2018, but the proportion is expected to increase to approximately 70% by 2050.[2] Rapid urbanization is associated with various economic, environmental, and social issues, including congestion, environmental degradation, social inequality, affordable housing, and public health.[3, 4, 5] Despite the burgeoning issues regarding urbanization, cities also play important roles as powerhouses of the national and global economy. 80% of the global GDP is generated in cities, and for OECD countries, 52% of the total GDP comes from metropolitan areas.[6, 7] Considering the threats and the significance of urban areas, there is increasing attention on the creation of a sustainable urban environment. Cities must adapt to the increasing urban population while maenaging the risks across various sectors.

1.2. Transport Sector Trend: Sustainability Issues of Transportation

With the rapid development of technology, people and goods are moving more and faster around the world. Compared to 2015, annual passenger traffic and global freight volume are expected to increase by 50% and 70% respectively by 2030.[8] In addition, total transport activity will more than double by 2050.[9] As the discourse on sustainable development receives increasing attention, the transport sector has emerged as a hot potato due to its connection to various factors of sustainability.

1.2.1. Energy & GHG

Despite the advent of various renewable energy sources, the largest source of energy for transportation today is still fossil fuels (95%), which accounts for 57% of the global oil demand.[10] As a result, the transport sector accounts for approximately 25% of the total GHG emissions.[9] Transportation is also the largest source of energy-related emissions for 45% of the countries; it is the second largest source for the rest of the countries.[10] Moreover, as transportation needs grow rapidly in developing countries, transportation-related GHG emissions also show the fastest growth rate in developing countries.[10]

1.2.2. Public Health

Transportation is also strongly associated with public health. Above all, transportation is a menace to public safety as it is a leading cause of injuries and deaths (e.g., vehicle-vehicle, vehicle-person accidents). The annual number of road traffic deaths amounts to 1.2 million, and as of 2019, road traffic crashes were the leading cause of death for individuals between the ages of 5 and 29, with more than two deaths occurring every minute.[11] Transportation also poses indirect threats to public health as the major source of air pollution and noise pollution. According to the World Health Organization (WHO), air pollution is a major environmental health problem, which is associated with various health risks such as cardiac and respiratory diseases.[12] Although often overlooked, noise pollution is another transport-related environmental health concern. Noise pollution is associated with sleep disturbances, cardiovascular diseases, and impaired performance. According to the European Environment Agency (EEA), 12,000 annual premature deaths, 6.5 million cases of chronic sleep disturbances, and 12,000 cases of learning impairment result from noise pollution.[13]

1.2.3. Accessibility and Inclusion

Lastly, accessibility to transportation is an important aspect of sustainability. More than a billion people lack access to all-weather roads, and only about 50% of the urban population have convenient (500 to 1,000m distance) to public transportation.[14, 15, 16] Limited provision of all-weather roads and public transportation hinders access to civil infrastructure and economic opportunities, thus contributing to socioeconomic polarization. It is also important to consider the inclusiveness of the transportation service provision. While 15% of the world's population has a disability, about 32% of public transportation facilities are not wheelchair-friendly.[16] Also, one in six women perceive public transportation as unsafe. These phenomena – limited accessibility and lack of inclusiveness – are especially prevalent in LMICs.

1.3. Green Growth Approaches

Green growth refers to "a strategic approach that prioritizes economic development and protecting the environment while increasing shared economic prosperity".[17] With the increasing emphasis on green growth, various approaches to green growth are occurring within the urban and transport sectors.

1.3.1. Informal Settlement Upgrading

Urbanization and informal settlements are closely interconnected. For every 1% increase in urban population, there is a 2.3% increase in the incidence of slums in Africa, and a 5.3% increase in Asia.[18] Approximately 25% of the world's urban population lived in slums or informal settlements in 2020, of which 85% are located in Sub-Saharan Africa (230 million), Central and Southern Asia (359 million), and Eastern and South-Eastern Asia (306 million).[19] It is also important to note that while the proportion of the population living in slums or informal settlements decreased from 31.2% in 2000 to 24.2% in 2022, the population increased in absolute numbers during the same period (from 895.9 million to 1.06 billion).[19] An increase in the number of informal settlement residents has multiple implications (TABLE 1). Therefore, upgrading informal settlements is significant in terms of contributing to the green growth of urban environments, both environmentally and socioeconomically.

TABLE 1. CONSEQUENCES AND IMPLICATIONS OF INCREASING INFORMAL SETTLEMENT RESIDENTS

Consequences of Increasing Informal Settlement Residents	Economic
Limited access to basic infrastructure and services including water, sanitation, and medical services	Public health risks
Overcrowding and lack of waste management	Environmental degradation (soil, water pollution)
Increasing vulnerability to climate hazards such as extreme heatwaves, floods, and infectious diseases	Increasing mortality
Tenure insecurity, unemployment, and poverty, combined with a lack of affordable housing	Social exclusion and marginalization, reduced economic potential

1.3.2. Green Mobility

With rapid urbanization and climate change, the transition to more sustainable modes of transportation is also strongly endorsed. As aforementioned, transportation is associated with economic, environmental, and social aspects of sustainability. Thus, holistic and multifaceted approaches are required to address the problems that humanity faces in the era of great transformation. In this turbulent time, the notion of green mobility is rising as one of the methodologies for a sustainable future. Green mobility revolves around four key factors: people, environment, economy, and institutions and relevant objectives (TABLE 2).[20] By facilitating improvements in these key factors, green mobility aims to not only mitigate but also adapt to climate change while fostering green growth.

TABLE 2. GREEN MOBILITY KEY FACTORS

Key Factors	Objectives
People	Provide safe, inclusive, accessible, and effective modes of green mobility
Environment	Reduce environmental effects (GHG emissions, air, and noise pollution) with the implementation of the green mobility system
Economy	Encourage local economic growth
Institutions	Enhance institutional, legal, and regulatory capabilities

1.4. Green Growth Approaches: Best Cases

1.4.1. Informal Settlement Upgrade: Agra, India

Agra, India is one of the cases where informal settlement upgrade has made significant progress in sustainable urban development. Famous for the Taj Mahal and other Mughal monuments, Agra is one of the famous tourist destinations in India. However, Agra's tourism potential resulted in uncontrolled urban expansion and the rapid increase of slum settlements. Before the implementation of the slum upgrade program in 2005, there were 252 slum areas and 120,000 slum dwellers in Agra, which was approximately 10% of the total city population.[21] Above all, the main concern in Agra was sanitation due to the lack of financial resources and technical capacity. To resolve this issue, the Cities Alliance and the United States Agency for International Development (USAID) worked in partnership with local communities and institutions. One of the key strategies was a community inclusion pilot program named the Crosscutting Agra Programme (CAP).

TABLE 3. AGRA PROGRAM DESCRIPTION[21]

	Program Description
1	Foster community inclusion and improve sanitation and urban livelihoods
2	Encourage women & youth participation - in the planning and implementation stages of sanitation and other local services
3	Increase the tourism potential of the private sector - develop tour routes in lesser-known heritage sites
4	Improve environmental conditions - collaboration with local companies & institutions
5	Development of the Community-Based Information System (CBIS) - integrated mapping system - treats both geospatial and socioeconomic information - help improve the efficiency of regeneration programs - output of the partnership with the Centre for Urban and Regional Excellence (CURE)

Key lessons:

1. Form partnerships with local stakeholders (e.g., public sector, private sector, local communities) and encourage local cooperation
2. Community inclusion is key to success (e.g., bottom-up process)
3. Improve both local hardware and software
4. Accessibility and inclusivity must be considered (e.g., female and youth participation)

1.4.2. Green Mobility: Jeju, South Korea

Jeju City, South Korea showcases an exemplary application of green mobility. Jeju City, a city of Jeju Island, has approximately 490,000 residents and a surface area of 977.9 km2. Since its designation as a UNESCO World Natural Heritage Site in 2007, Jeju Island has become a primary destination for domestic and international tourists; more than 10 million tourists visit Jeju Island every year. Due to the rapid expansion of tourism and urbanization, transportation needs in Jeju increased. Multiple modes of public transportation, including buses, scooters, and bikes are provided across Jeju Island, but the dominant form of transportation is personal vehicles. Compared to 2010 when there were about 250,000 registered vehicles, there are more than 590,000 vehicles as of 2023. In addition, the growth of car rental services has also contributed to congestion, car accidents, and environmental degradation across Jeju Island.

To address local issues and adhere to the Korean government's 2030 NDC goal of reducing 37.8% of GHG emissions in the transport sector, Jeju City adopted green mobility strategies for sustainable growth.[22] Green mobility is also a key focus in transforming Jeju into a net-zero island upon the Carbon Free Island Initiative 2030. Adopted green mobility programs are listed below (TABLE 4).

TABLE 4. JEJU PROGRAM DESCRIPTION[20 23]

	Program Description
1	Extensive and interconnected public bus system that serves both residents and tourists
2	Transition to electronic vehicles (buses, taxis, and cars) & renewable energy - policies incentivizing the use of EVs (Jeju has the highest proportion of EVs in South Korea) - develop EV-friendly infrastructure (e.g., increase charging stop installation)
3	Promote alternate modes of green transportation - electronic scooters and bicycles (e.g., "GreeGo" application to rent nearby e-scooters and bikes) - improve bike lanes and free public shared bikes
4	Improve pedestrian environment - pedestrian-friendly roads (improve & extend pedestrian networks) - safe and pleasant walking environment (e.g., vehicle-restricted zones in Nuwemaru)
5	Grow green mobility sentiment - host walk festival (e.g., Olle Walking Festival, education campaigns) - implement pro-environment policies and clean energy solutions - free bus transfers (within 40min, up to 2 transfers)
6	Enhance accessibility and inclusivity - free transportation service for people aged 70+ or individuals with disabilities - wheel-chair friendly transportation (e.g., low-floor buses, wheelchair ramps) - funded on-demand taxi service ("haengbok (happiness) taxi") for elderlies aged 70+

Key lessons:

1. Promote a city-wide agenda for sustainable development
2. Encourage coordination between the public and private sectors, across multiple sectors (e.g., environment, social, transport, tourism)
3. Improve physical infrastructures that enhance the use of environmentally friendly modes of transportation and walkability
4. Adopt policies that enhance accessibility and inclusivity

1.4.3. Analysis

TABLE 5. SIMILARITIES AND DIFFERENCES BETWEEN AGRA AND JEJU PROGRAMS

Similarities	Differences
Promote social inclusion	Agra's community-based & bottom-up process vs. Jeju's top-down process
Encourage coordination between various stakeholders	
Improve environmental conditions	
Enhance economic potential	Agra is more focused on resident livelihoods vs. Jeju is more focused on environmental implications
Strengthen institutional foundation	
Application of technology	

The Korea Green Growth Fund (KGGTF) serves its purpose of supporting countries to operationalize green growth. Taking into account the lessons from previous practices and their formulas for success, the following chapters delve into the grant programs led by the KGGTF, and how the grants help the target countries to achieve green growth.

2. GRANT CASE STUDY 1: METRO MANILA, PHILIPPINES

2.1. Summary of the Grant

The Philippines is rapidly urbanizing, with over 56% expected to live in cities by 2050. Metro Manila, the largest urban center, has around 600,000 informal settler families (ISFs), which is about 40% of the total number in the country. [24] One in every four people in this megacity is an informal settler, and the population grew by 62.5% between 2006 and 2010. In 2011, the national government embarked on a large-scale resettlement program to relocate ISFs living in danger areas, principally those inhabiting the easement of Metro Manila's waterways. While the intent of the initiative, as stated in the policy, is to encourage a shift in favor of in-city housing, in practice, about 70% of relocated ISFs went to off-city sites with failure to implement in-city housing.

Due to the lack of affordable housing in Metro Manila, providing safe shelters to ISFs has become one of the country's most prioritized urban issues. In this regard, due to the growing need for housing and services for ISFs, the traditional program-based approach has proven to be ineffective. Therefore, it is crucial to explore a more programmatic approach that allows the government to address the housing issue at scale in a timely manner. To achieve this, the Social Housing Finance Corporation (SHFC) and the World Bank launched a pilot of the Citywide Community Upgrading Strategy (hereafter referred to as the Citywide Strategy) in Metro Manila.

The grant has identified three pilot sites across different Barangays in the cities of Muntinlupa, Quezon, and Caloocan. These sites were carefully chosen based on various criteria such as the presence of active Civil Society Organizations (CSOs), the local government unit's receptiveness, existing participatory development initiatives, and alignment with the World Bank's flood control program.

2.2. Indicative Investment Priorities

The strategy Citywide is focused on addressing obstacles to in-city housing from the demand side, with a particular focus on the lack of a coherent shelter plan and participation of ISFs and CSOs in city development processes. The strategy's objective is to consolidate and channel demand for in-city housing from ISF communities to public and private institutions, aligning with local government initiatives.

The strategy is guided by key features, including citywide mapping, orchestrated processes by Local Government Units (LGUs), program planning driven by the community, and a broad partnership involving multiple stakeholders such as communities, governments, CSOs, professionals, and financial institutions. A new financing mechanism, which encompasses funds from multiple sources, is introduced to support social organizing, program development, land acquisition, site development, and housing construction. The integrated approach goes beyond housing to address broader social, economic, and environmental issues that are integral to community development.

The Citywide process's outputs include updated mapping and socio-economic data on ISFs, an inventory of available land, a digitized GIS map, a comprehensive shelter development plan incorporated into the LGU's Comprehensive Land Use Plan and City Development Plan, and identification of housing programs for priority communities. The strategy emphasizes community involvement, multi-stakeholder collaboration, and an inclusive, holistic approach to address housing and broader development concerns.

In the pilot program, a city shelter plan is the primary instrument for creating effective demand, with the aim of adoption by the local government and integration into city development and land use plans. Components of the proposed citywide strategy include city-wide mapping, needs assessment, prioritization, fund mobilization, program planning, and implementation, along with continuous monitoring and evaluation
The pilot programs have multiple expected outcomes that address informal settler communities' housing needs and socio-economic conditions. These outcomes collectively contribute to a comprehensive urban development strategy that addresses not just housing needs, but also socio-economic factors and community involvement. The programs aim to create a sustainable and inclusive urban environment through the active participation of key stakeholders, as well as the implementation of various measures.

2.3. Stakeholder Roles and Involvement

The common facts regarding the stakeholders' relationship in the three pilot programs are characterized by multi-sectoral collaboration and diverse involvement across government bodies, community organizations, and civil society entities. In the Muntinlupa City pilot program, a partnership is forged among the city government, specifically the Urban Poor Affairs Office (UPAO) and City Planning and Development Office (CPDO), along with the ISF communities. This collaboration extends to people's organizations, neighborhood associations, and homeowners' associations. Furthermore, the Homeless People's Federation Philippines, Inc. (HPFPI) and the Muntinlupa Development Foundation (MDF) play supporting roles by assisting communities with mapping and profiling activities. The Technical Assistance Movement for People and Environment, Inc. (TAMPEI) provides technical expertise in shelter planning.

The Quezon City pilot program collaboration involves the city government's Housing, Community Development, and Resettlement Department (HCDRD), CPDO, Assessor's Office, and Engineering Office. The engagement of local organizations, particularly the Alyansa ng Maralita sa Novaliches (ALMANOVA) and the Federation of Homeowners' Associations in Baesa, further highlights the diverse stakeholder engagement in addressing urban development challenges.

The Barangáy 177 pilot program in Caloocan City emphasizes key stakeholders such as the Barangáy Local Housing Office (LHO), the non-governmental organization Foundation for the Development of the Urban Poor (FDUP), and the Nagkakaisang Samahan ng Mga Maralita sa Barangáy 177 (NASAMA). Notably, a barangáy-wide network comprising twenty informal settler community organizations adds depth to the community-centric approach. ALTERPLAN, a lead CSO, provides technical assistance in the Quezon City pilot program, showcasing the vital role of CSOs in the urban development landscape.

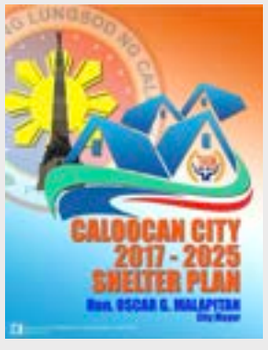
These pilot programs share common ground in their commitment to collaborative approaches involving government entities, local communities, and CSOs. This multi-stakeholder engagement underscores the comprehensive strategies required for addressing the intricate challenges of urban development in diverse contexts.

[Special Section]

Overview of Caloocan City's 2025 Local Shelter Plan after the grant program[25]

The Caloocan City plans outlined in the Metro Manila Citywide program laid the groundwork for subsequent developments in the Caloocan City's 2017-2025 Local Shelter Plan. The Metro Manila Citywide program, implemented by the KGGTF in 2016, would played a pivotal role in shaping the city's approach to informal settlement upgrading and housing development.

In the Metro Manila Citywide program, a comprehensive stocktaking of the informal settlement upgrading approach was conducted. This involved assessing the existing conditions, challenges, and opportunities related to informal settlements in Caloocan City. The program emphasized the importance of a citywide strategy for addressing the complex issues associated with informal housing.



One of the key takeaways from the Metro Manila Citywide program was the identification of specific areas within Caloocan City that required targeted interventions. The analysis of informal settlements, population distribution, and land use patterns provided valuable insights into formulating effective strategies. This data-driven approach laid the foundation for more nuanced and tailored solutions in the subsequent Local Shelter Plan.

The emphasis on community engagement and stakeholder collaboration, as highlighted in the Metro Manila Citywide program, influenced the participatory nature of the Caloocan City's 2017-2025 Local Shelter Plan. The involvement of various stakeholders, including government agencies, private sector entities, and local communities, was underscored as a crucial element in achieving sustainable and inclusive development.

Furthermore, the Metro Manila Citywide program highlighted on the importance of aligning housing initiatives with broader urban development goals. The emphasis on integrated land use planning and disaster risk reduction strategies was carried forward into the Local Shelter Plan. This integration aimed to create resilient and environmentally sustainable communities, addressing both immediate shelter needs and long-term urban planning considerations.

The experience gained from the Metro Manila Citywide program also prompted a more robust focus on financing mechanisms within the Caloocan City's 2017-2025 Local Shelter Plan. The recognition of the need for diverse funding sources, including government financing instruments, private sector investments, and partnerships, became a cornerstone for ensuring the financial sustainability of shelter initiatives.

In terms of monitoring and evaluation, the Metro Manila Citywide program advocated for a systematic tracking system, which was subsequently incorporated into the Local Shelter Plan. The establishment of a monitoring and evaluation system, involving the Caloocan City Local Housing Board and various stakeholders, reflected a commitment to transparency and accountability in the implementation of shelter-related strategies.

The Metro Manila Citywide program can be seen as a preliminary blueprint that guided the evolution of Caloocan City's approach to informal settlement upgrading and housing development. It provided a diagnostic lens to understand the challenges and opportunities within the city, laying the groundwork for a more refined and strategic Local Shelter Plan from 2017 to 2025.

3. GRANT CASE STUDY 2: SIEM REAP, CAMBODIA

3.1. Summary of the Grant

Siem Reap, located in northwest Cambodia, has seen a substantial urban spread since its UNESCO designation in 1992, with the city's area expanding by 160% from 2004 to 2017. Its proximity to the Angkor World Heritage Area positions it as Cambodia's tourism focal point, which compounds its urban and transportation challenges. The current infrastructure is not conducive to green mobility, with prevalent use of motorbikes and limited transportation options leading to accessibility issues, environmental concerns from transport emissions, and traffic problems that could potentially deter tourism and affect the city's charm.

The city is at a crossroads, with a 2035 Land Use Plan projecting a 50% population growth. This growth necessitates a strategic approach to urban development and transportation. Siem Reap must decide whether to continue with a vehicle-centric growth model or pivot towards sustainable green mobility, balancing development with the preservation of its UNESCO sites.

Green Mobility emerges as a pivotal solution to these challenges. This concept involves reducing greenhouse gas emissions and air pollution through active mobility, such as walking and cycling, alongside the promotion of public transport and e-mobility infrastructure. Not only does it aim to address environmental concerns, but it also seeks to foster a shift in public sentiment towards sustainable travel practices.

The vision for Green Mobility in Siem Reap is delineated by four main goals (TABLE 6) catering to the needs of residents for daily commute and leisure, as well as offering tourists a convenient travel experience to major attractions. The plan calls for a substantial investment of approximately $220.3 million over the next decade, which will fund an array of initiatives. This includes showcasing a new electric public transport system, expanding extensive cycling and walking paths in sync with road and river improvements, and enhancing road networks for all-weather use.

TABLE 6. DESCRIPTION OF THE FOUR KEY GOALS

Goal		Description
1	People	Creating a people-centric, integrated green mobility system that moves all people safely, securely, and effectively
2	Environment	Reducing emissions and improving air quality by facilitating the transition to green mobility by building sentiment and changing behavior, while also responding to climate change.
3	Heritage & Tourism	Preserving and respecting heritage, while accentuating heritage and broadening tourism through green mobility
4	Institutional	Creating an enabling framework to facilitate and encourage green mobility

Two corridors, NR6 and Sivutha Blvd., are prioritized to lay the groundwork for green transit in the city. Moreover, four pilot programs are identified to test pedestrianization efforts, traffic calming measures, and parking management strategies. These programs are expected to serve as a foundation for wider implementation across Siem Reap. To facilitate these transformations, a suite of institutional strengthening and financing measures have been identified, aiming to create a conducive environment for the adoption of Green Mobility.

3.2. Indicative Investment Priorities

Siem Reap's Green Mobility initiative, aiming to establish a sustainable transport system with a $220.3 million budget over a decade, unfolds in two phases. The first phase, spanning the initial seven years with a budget of $123.4 million, concentrates on building a foundational infrastructure for active mobility, such as walking and cycling paths, and initiating a green public transportation system. It also includes upgrading the road network for safety and testing innovative solutions through pilot programs.

The second phase, in the final three years with $96.9 million allocated, expands upon these foundations. It aims at advancing e-mobility, integrating green mobility into new developments, and enhancing policies and incentives for sustainable transport. Efforts to connect heritage sites with green mobility options and to improve parking and traffic management are prioritized, alongside establishing a resilient and people-centric urban mobility framework.

This strategic investment not only focuses on physical infrastructure improvements but also on fostering a culture of sustainability, aiming to position Siem Reap as a benchmark city for green transportation globally.

3.3. Implementation

Siem Reap's Green Mobility Strategy outlines a transformative approach to upgrading the city's transportation infrastructure with a focus on sustainability, safety, and efficiency. Here's a condensed overview:

Road Network Enhancement: Plans to upgrade 65 kilometers of roadways with a $108.9 million investment include improving pavement, drainage, pedestrian access, and incorporating pedestrian-friendly features like modern crossings, lighting, tree planting, and street furniture. This two-phase, ten-year program aims to enhance all-weather road usability, multimodal transport, and city connectivity.

Electric Public Transport Network: With a $15.92 million budget, the strategy aims to establish an electric bus network across eight routes covering 210km, connecting key areas to promote a sustainable, low-emission public transport option. This initiative addresses the challenge of integrating a new public transport system into the city.

Bike Network: The strategy envisions a comprehensive bike network with dedicated and shared lanes over 165.2km total, incorporating features like bike racks and sharing programs. This network is designed to encourage cycling as a primary mode of transport, reduce vehicular traffic, and support healthier lifestyles.

Walk Network: Investing approximately $32.7 million to improve pedestrian infrastructure, the plan focuses on enhancing 75.3km of sidewalks and crossings to make walking a safer, more enjoyable option, supporting public transport use and reducing short-trip motorbike dependency.

Overall, the Green Mobility Strategy for Siem Reap aims to revamp the city's transport system by prioritizing green, efficient, and safe mobility solutions, contributing to economic growth and environmental sustainability.

3.4. Stakeholder Roles and Involvement

In Siem Reap, the Green Mobility initiatives represent a concerted effort between various government levels and the private sector, each playing a crucial role in the successful deployment and maintenance of green mobility solutions. This collaborative approach ensures comprehensive management across all mobility facets, including road enhancements, public transportation, cycling infrastructure, and pedestrian pathways.

The Ministry of Public Works and Transport (MPWT) spearheads the planning and construction of national and provincial roads to align with green mobility standards, while the Department of Public Works and Transport (DPWT) focuses on maintaining these roads beyond the city center. The Ministry of Economy and Finance (MEF) secures and manages the funding for these improvements, highlighting the importance of financial oversight in sustainable infrastructure development.

For local road improvements, the Provincial Government takes the lead, emphasizing green mobility integration within its planning and funding efforts. The Department of Rural Development addresses the rural road enhancements critical for ensuring wider accessibility and connectivity.

Public transport initiatives are proposed to be managed by the MPWT, with plans for the establishment of a Future Transport Authority to ensure efficient operation and regional integration, signaling a move towards involving the private sector in funding and maintenance.

The Provincial Government is also tasked with managing cycling improvements and sidewalk enhancements, ensuring that bike lanes, bike-sharing programs, and pedestrian pathways are safely and effectively integrated into the urban fabric. This includes coordinating across jurisdictions and possibly engaging private sector partnerships for operation and maintenance.

Parking improvements are under the purview of the Provincial Government, with enforcement roles assigned to the Traffic Police, aiming to refine parking solutions and enhance traffic management.

This strategic partnership across government bodies and with the private sector underscores a multifaceted approach to developing a sustainable, efficient mobility ecosystem in Siem Reap, ensuring that each initiative is well-supported and aligns with the overarching goals of green mobility.

4. EVALUATIONS: CONTRIBUTIONS AND LIMITATIONS

4.1. Urban Sector (Contributions/Limitations to Sustainable Development)

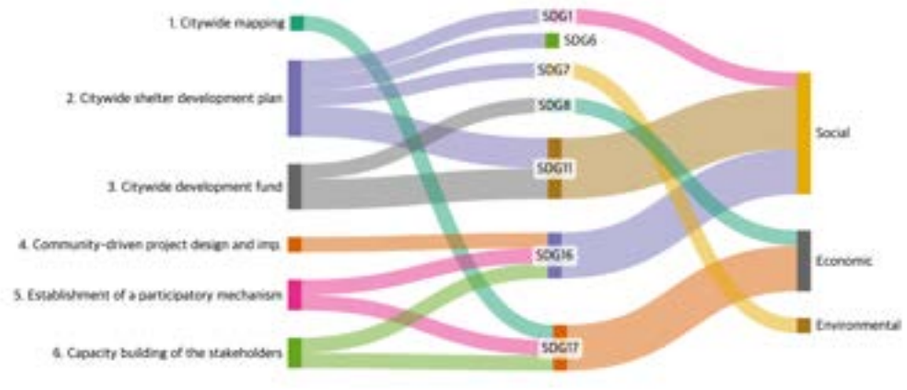


FIGURE 1. DIAGRAM OF THREE PILLARS OF SUSTAINABILITY THAT EACH TARGET GOAL RELATED
(Source: Illustrated by author using SankeyMATIC)

FIGURE 1 shows how the Sustainable Development Goals (SDGs) related to housing settlement connect to each target goal. The Citywide program is currently implementing six target outputs in the pilot sites, which include Citywide mapping, Citywide shelter development plan, Citywide development fund, Community-driven program design and implementation, Establishment of a participatory mechanism, and Capacity building of stakeholders. The overarching goal of the Citywide program aligns with SDG11, which seeks to create inclusive, safe, resilient, and sustainable cities and human settlements. Specifically, the Citywide program aims to achieve target 11.1 of SDG 11, which focuses on ensuring access for all to adequate, safe, and affordable housing and basic services, as well as upgrading slums.

In addition, the three programs have common themes centered around the objectives of poverty alleviation and community engagement, which align with SDGs 1 and 17. Each program aims to improve living conditions and establish secure land tenure for residents in informal settlements. Collaboration between NGOs, LGUs, and community associations highlights a multi-stakeholder approach to development.

In Muntinlupa City, the program aligns with SDG 11 by targeting informal settlements and aspiring to create inclusive, safe, resilient, and sustainable urban areas. The emphasis on community-driven development and the formulation of shelter plans reflects a commitment to sustainable urbanization. However, a more detailed examination of sustainability measures would provide a comprehensive understanding of the program's impact. In Quezon City, the program also aligns with SDG 11, emphasizing sustainable urban development through the addressing of informal settlements. The integration of government programs and the development of a district shelter plan showcase efforts toward inclusive and sustainable city planning. However, more participation from residents is necessary to achieve the desired results. For Caloocan City, the program addresses poverty through evidence-based and participatory planning for socialized housing, which aligns with SDG 1. The focus on Barangay 177 as a pilot site allows for targeted efforts in collecting household census data, developing program proposals, and creating a disaster-sensitive Barangay Shelter Development Plan. The collaboration between NGOs, the Barangay government, and community organizations aligns with SDG 17.

The examined pilot programs generally need explicit plans or strategies to create career opportunities for ISFs. While the programs discuss housing, shelter plans, and community development, there's limited emphasis on

addressing the economic aspects of poverty. Incorporating targeted measures for skills development, vocational training, and job creation within these programs would contribute to the economic empowerment of ISFs. Providing avenues for stable employment and income generation aligns with SDG 8, which emphasizes decent work and economic growth. Integrating career development initiatives could enhance the overall sustainability and impact of the programs on the lives of the ISFs.

Contributions to Sustainable Development

The Citywide Community Upgrading Strategy in Metro Manila significantly contributes to economic sustainability by addressing poverty among ISFs. The provision of affordable housing and community development initiatives aims to uplift ISFs from poverty and improve their overall economic well-being. Additionally, the programs promote decent work and economic growth by creating opportunities for skills development, vocational training, and job creation within informal settlements.

Aligned with SDG 17, the programs emphasize collaboration between NGOs, LGUs, and community associations, fostering community engagement and building resilient communities. The multi-stakeholder approach ensures a sense of ownership among residents, contributing to social cohesion. Furthermore, the programs positively impact residents' health in the long term, aligning with SDGs 3 (Good Health and Well-being) by providing access to adequate housing and secure land tenure.

The core focus on sustainable urban development in the programs aligns with SDG 11 (Sustainable Cities and Communities). By targeting informal settlements and aspiring to create inclusive, safe, resilient, and sustainable urban areas, the programs contribute to environmental sustainability. To extend in long terms, disaster-sensitive shelter development plans address climate vulnerabilities, aligning with SDG 13 (Climate Action) and enhancing overall climate resilience.

According to the pillars of sustainability, the SDGs can be categorized into three pillars: Social, Economic, and Environmental. Paolo and Addeo's research (2019) shows that the SDGs can be grouped into these pillars.[26] The social pillar encompasses six target goals, the economic pillar contains four, and the environmental pillar has one. After evaluating target goals against SDGs and sustainability, it was found that pilot programs were more focused on social and economic pillars but lacked attention to environmental pillars.

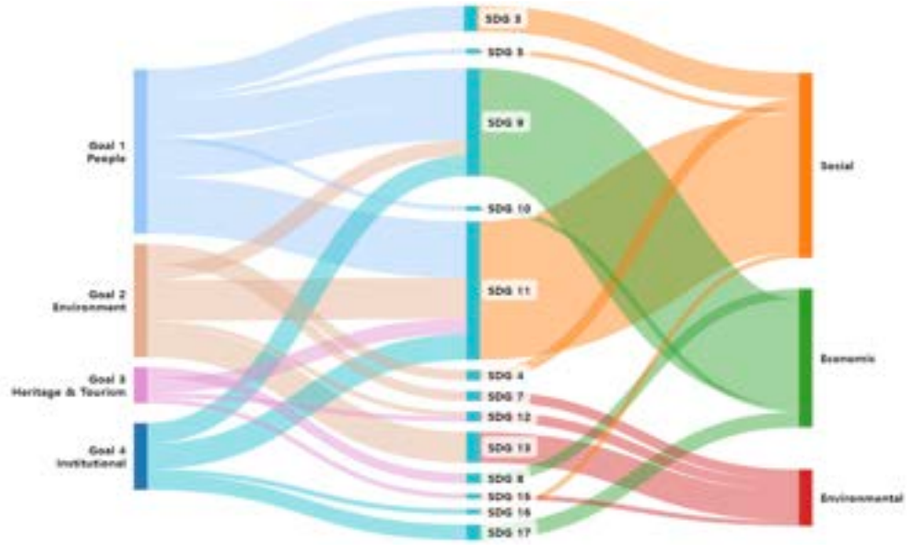


FIGURE 2. RELATIONSHIP BETWEEN EACH GOALS AND SDGS

4.2. Transportation Sector

Siem Reap's Green Mobility initiative is a comprehensive strategy to revamp its transportation system, aligned with SDGs to promote sustainability. This strategy focuses on four main areas: People, Environment, Heritage & Tourism, and Institutional frameworks, aiming to create an integrated green mobility system.

- **People:** This goal emphasizes safety, inclusivity, and mobility for all, supporting SDGs related to health, equality, and sustainable cities. Initiatives include developing pedestrian and cycling infrastructure and improving road safety, ensuring accessibility for everyone, including women and disadvantaged groups.

- **Environment:** Aiming to reduce environmental impact, the initiative supports clean energy, climate action, and sustainable urban development SDGs. Efforts to boost e-mobility, reduce vehicle pollution, and design resilient transportation systems are central to reducing emissions and promoting environmental health.

- **Heritage & Tourism:** Strategies focus on preserving Siem Reap's cultural heritage while fostering sustainable tourism growth, in line with SDGs on economic growth, sustainable cities, and life on land. Enhancements to green mobility are crafted to protect heritage sites, connect attractions sustainably, and bolster local economies without compromising cultural integrity.

- **Institutional:** The success of the initiative depends on a solid institutional framework that supports innovation, infrastructure, justice, and partnerships, as outlined in related SDGs. This involves developing user-centered design frameworks, leveraging technology, strengthening legal and regulatory frameworks, and identifying new funding mechanisms to sustain transportation initiatives.

By integrating these strategic pillars, Siem Reap's Green Mobility initiative takes a holistic approach to urban transportation, aligning with global sustainability goals to ensure a resilient, inclusive future for the city.

Contributions to Sustainable Development

The Green Mobility initiative in Siem Reap is a comprehensive strategy crafted to resonate with SDGs, aiming to transform the city's transportation landscape into a model of sustainability that embraces environmental, economic, and social pillars.

Environmental Sustainability: Centered around reducing emissions, enhancing energy efficiency, and protecting ecosystems, the initiative's efforts align with SDGs 7, 12, 13, and 15. Through the promotion of e-mobility and the adoption of cleaner vehicles, it aims to lessen energy consumption and safeguard natural habitats, thereby contributing significantly to climate action and the preservation of terrestrial ecosystems.

Economic Sustainability: By integrating sustainable urban mobility with economic development and innovation, the initiative supports SDGs 8, 9, 10, and 17. It focuses on boosting economic productivity, fostering innovation, and ensuring that economic growth is inclusive, offering benefits across all societal segments. Investment in green mobility infrastructure is expected to drive local economic growth and attract sustainable investments.

Social Sustainability: Prioritizing accessibility, safety, and inclusiveness, the strategy aligns with SDGs 3, 4, 5, 11, and 16. Through developing comprehensive pedestrian networks and enhancing safety measures, it seeks to make transportation equitable and secure for all community members, including vulnerable groups, thereby fostering a more healthful, safe, and cohesive society.

Overall, Siem Reap's Green Mobility initiative illustrates a strategic approach to leveraging urban transportation as a catalyst for sustainable development, aiming to achieve a harmonious balance between environmental integrity,

economic viability, and social equity.

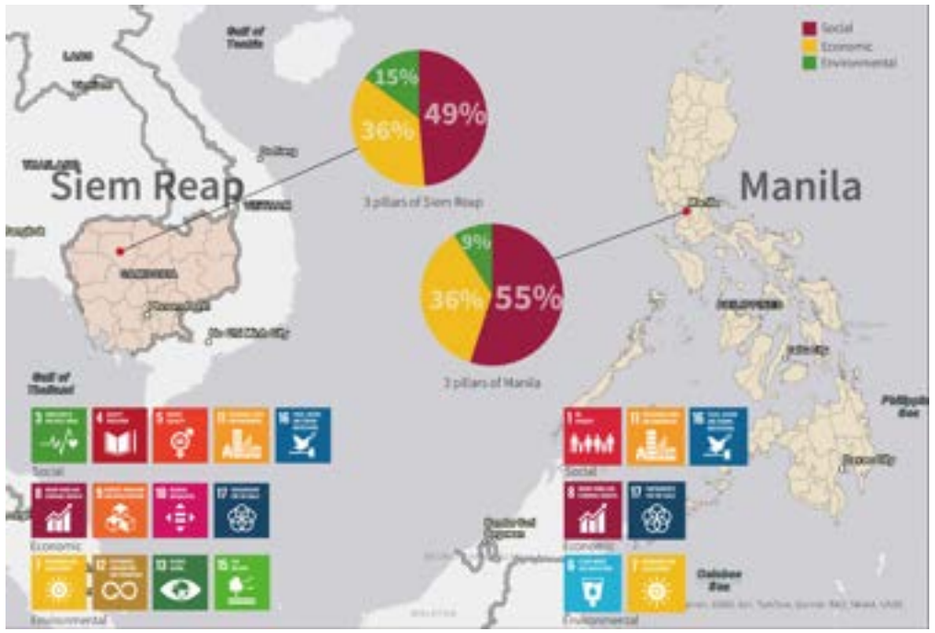


FIGURE 3. COMPARATIVE ANALYSIS OF METRO MANILA AND SIEM REAP
(Source: Illustrated by author Doyun Lee)

4.3. Comparative Analysis of Metro Manila and Siem Reap Programs

Both the Metro Manila and Siem Reap programs exhibit unique features and contributions, along with inherent limitations. A comparative analysis provides insights into their distinct approaches, emphasizing both successes and challenges.

The Citywide Strategy in Metro Manila contributes significantly to addressing the issue of informal settlements. By focusing on in-city housing demand, the program introduces a programmatic approach, emphasizing community-driven processes, multi-stakeholder collaboration, and the integration of funds from various sources. The strategy's emphasis on comprehensive mapping, socio-economic data, and shelter development plans aligns with SDG 11, aiming to create inclusive, safe, resilient, and sustainable cities.

Siem Reap's Green Mobility initiative makes substantial contributions to sustainable urban development amid tourism growth. The program prioritizes active mobility promotion, public transport enhancement, and infrastructure improvements, aiming to reduce environmental impact and foster a shift towards sustainable travel practices. The proposed investment of $220.3 million over a decade demonstrates a commitment to comprehensive solutions for addressing urban challenges, aligning with SDG 11, 13, and 9.

Despite its contributions, the Citywide Strategy faces challenges such as limited resident participation, economic empowerment strategies for ISFs, and the full integration of plans into local government initiatives. There is a need for more explicit economic development plans within the strategy to enhance the overall sustainability and impact on the lives of ISFs.

While addressing key urban challenges, the Green Mobility initiative in Siem Reap faces obstacles such as the potential disruption of tourism due to traffic management and parking improvements. Additionally, the program requires robust stakeholder involvement at both national and provincial levels, and there might be challenges in coordinating these efforts effectively.

TABLE 7. COMPARATIVE TABLE OF TWO GRANT PROGRAMS

Aspect	Metro Manila Program	Siem Reap Program
Program Focus	Informal settlement housing demand	Sustainable urban development and green mobility
Financial Investment	Not specified	$220.3 million over a decade
Stakeholder Collaboration	Multi-sectoral collaboration involving government, communities, and CSOs	Collaboration at national and provincial levels, involving various stakeholders
Sustainable Development Goals	Emphasizes SDG 11 (Sustainable Cities and Communities)	Aligns with SDGs 11 (Sustainable Cities and Communities), 13 (Climate Action), and 9 (Industry, Innovation, and Infrastructure)
Challenges	Limited resident participation, economic empowerment strategies for ISFs, and integration into local government plans	Potential tourism disruption, coordination challenges, and stakeholder involvement at different levels

Both programs share common contributions to sustainable urban development. They emphasize a comprehensive approach, addressing multifaceted urban challenges. The Metro Manila program focuses on informal settlement housing demand, fostering inclusivity and safety. In contrast, the Siem Reap program prioritizes green mobility, aligning with environmental sustainability goals.

Common limitations include the need for enhanced resident participation, economic empowerment strategies, and effective integration into local government plans. Both programs face challenges in fully realizing the economic aspects of poverty and fostering sustainable livelihoods for the communities involved.

4.4. Recommendations for Future Programs

1) **Enhanced Community Involvement:** Future programs should prioritize robust community involvement strategies, ensuring that residents actively participate in the decision-making processes. This can be achieved through targeted outreach, awareness campaigns, and inclusive participatory mechanisms.

2) **Explicit Economic Development Plans:** To address economic limitations, programs should incorporate explicit plans for economic empowerment. This could involve measures such as skills development, vocational training, and job creation, aligning with SDG 8 (Decent Work and Economic Growth).

3) **Coordinated Stakeholder Engagement:** Effective collaboration among diverse stakeholders is crucial. Future programs should establish clear mechanisms for coordination, ensuring that national, provincial, and local entities work cohesively towards shared objectives.

4) **Adaptability to Local Contexts:** Programs should be adaptable to the unique contexts of the areas they aim to impact. Considering the specific challenges and opportunities of each location is essential for successful implementation.

5) **Local-customized Sustainability Measures or Evaluation Systems:** Sustainability measures should extend beyond housing or mobility and address broader economic, social, and environmental aspects. A measurement or an evaluation system that reflecting regional characteristics ensures that programs contribute to comprehensive urban development.

While the Metro Manila and Siem Reap programs differ in their focus areas, they share common contributions and face similar limitations. Recommendations for future programs emphasize the importance of community involvement, explicit economic development plans, coordinated stakeholder engagement, adaptability to local contexts, and a holistic sustainability approach. These considerations can enhance the effectiveness and impact of urban development initiatives globally.

5. CONCLUSION

5.1. Summary and Key Lessons

The grant programs in Metro Manila and Siem Reap represent innovative responses to the complex challenges of urbanization. Metro Manila's Citywide Strategy aims to address informal settlements, emphasizing a programmatic approach and fostering collaboration among diverse stakeholders. Siem Reap's Green Mobility initiative tackles urban and transportation challenges posed by tourism growth, prioritizing sustainable and green transport solutions. Both programs underscore the importance of comprehensive and inclusive urban development. The Citywide Strategy integrates various funding sources to support social organizing, land acquisition, and housing construction, reflecting a commitment to addressing multifaceted urban issues. Siem Reap's Green Mobility plan allocates a substantial budget of $220.3 million, highlighting strategic financial planning for sustainable urbanization.

Stakeholder collaboration is a common theme in these programs. Metro Manila emphasizes partnerships among government bodies, communities, and CSOs. Siem Reap's Green Mobility involves collaboration at both national and provincial levels, recognizing the necessity of coordinated efforts for effective urban development. Sustainable urbanization emerges as a shared goal in both contexts. Metro Manila strives to create inclusive, safe, resilient, and sustainable urban areas through the Citywide Strategy. Siem Reap's Green Mobility plan seeks to balance development with environmental preservation, promoting a shift toward sustainable travel practices.

However, both programs face challenges, including limited resident participation, economic empowerment strategies, and full integration into local government plans. Recommendations include enhancing community involvement, implementing explicit plans for economic development, and ensuring comprehensive alignment with local government initiatives. The grant programs in Metro Manila and Siem Reap showcase innovative approaches, contributing to the broader vision of creating inclusive, resilient, and sustainable urban environments. These endeavors exemplify the importance of adapting strategies to unique urban contexts while addressing the diverse facets of urban development.

5.2. Youth Perspective: Formula for Green Growth

$$V_1 + V_2 + V_3 + V_4 + V_5 = \text{Green Growth}$$

In fact, the notion of green growth is very complex and comprehensive. Nonetheless, there is also a need to simplify the concept in order to provide a visible, concrete, road to approach green growth. Not all nations have the capabilities to create all of the necessary conditions to promote green growth. Therefore, as a concluding remark, this paper aims to summarize the necessary variables for achieving green growth based on the grant funded by the KGGTF.

Variable 1: Environmental Protection

The KGGTF grant programs are explicitly concerned with reducing the risks of environmental degradation. Various methods are introduced by the KGGTF to reduce pollution across multiple sectors including soil, air, and water. Reducing GHG emissions is also one of the main objectives of the KGGTF grants. Moreover, the grant programs underline the significance of understanding the contexts of the target nations to form feasible schemes.

Variable 2: Technology

The role of technology, especially ICT, is expanding in the urban and transport sectors in terms of addressing the challenges regarding green growth. The significance of collecting and utilizing data is evident, but developing countries often lack both social and physical infrastructure. To resolve these challenges, the KGGTF grant programs present the ways through which knowledge and technology can be transferred or improved and sustainable economic foundations established.

Variable 3: Inclusivity

The notion of inclusivity is now considered one of the key components of sustainability. Therefore, the KGGTF grant programs promote diversity-conscious and people-centric visions, multi-stakeholder coordination, and education. Through creating an inclusive environment, regardless of gender, race, disability, or other diversity factors, the KGGTF helps break down the barriers to development.

Variable 4: Resilience

Creating a safe environment is also highlighted throughout the KGGTF grant programs. Public health considerations are taken into account, and inclusivity (e.g., female, youth, and disability) factors are also being incorporated into creating a safe and resilient environment. The role of policy and institutions is also reinforced to adjust the foundation.

Variable 5: Economic Sustainability

Economic sustainability is another crucial factor for promoting green growth. The KGGTF grant programs help provide localized economic foundations in order to incentivize the local participants to continue their endeavors beyond the grant's timeframe. It is important to recognize that the attempts are not transient but permanent.

* It is important to note that the above variables of green growth are not mutually exclusive; their intimate interconnections reflect the sophisticated nature of green growth.

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WATER SECURITY AND GREEN GROWTH IN THE SOUTH OF ANGOLA: KGGTF'S WATER GRANT AS A CASE STUDY


Kyunghun Choi


Jiyeon Park


Hanna Choi*

ABSTRACT

The global water sector is currently navigating a critical phase, with escalating challenges posed by climate change and population growth reshaping its landscape.1 Understanding and addressing complex dynamics are crucial, as water scarcity is becoming an increasingly prevalent issue in many regions. The importance of green growth is thus emphasized as a key solution. The concept of water and green growth emphasizes the role of water in economic development, protection of the ecosystem, and social equity.[5]

The collaborative grant, "Water Security and Drought Resilience in the South of Angola," involving the World Bank Group, Korea Green Growth Trust Fund (KGGTF), and Global Water and Sanitation Partnership (GWSP) addresses the pressing issue of drought and water insecurity in southern Angola, particularly considering the devastating drought experienced from 2012 to 2020. It identifies key vulnerabilities such as lack of information, inadequate investments, inefficient infrastructure, and limited institutional capacity. The program utilizes satellite and census data to identify vulnerable areas, focusing on hydrological and geological factors. It prioritizes surface water harvesting and sand dams in Cunene and Namibe provinces while exploring groundwater potential. Recommendations include investing in knowledge, community infrastructure, institutional capacity, strengthening water point monitoring, sustainable water resource programs, and strategic planning. It underscores the importance of good data and ongoing policy dialogue. The program addresses a starting point for collaboration with the Angolan government, outlining future steps for community-based management and capacity building.

The KGGTF has played a significant role in supporting water sector programs by providing innovative and sustainable growth strategies and investments to developing countries, drawing from successful experiences of Korea. Liaising with the public and private stakeholders in Korea, the KGGTF has proposed effective strategies for water-related programs, including the aforementioned program.

The program contributes to the three pillars of sustainable development: social, environmental, and economic, as it stresses the importance of green growth. Engaging communities is vital for sustainability. Community involvement helps combat stunting and prepares communities for droughts, reducing livelihood costs. Furthermore, the program emphasizes sustainable water management through technologies like sand dams and managed aquifer recharge. By prioritizing environmental sustainability in its Nature-based Solutions (NBS) strategies, the program contributes to the preservation and restoration of local ecosystems that ensure long-term environmental integrity and resilience. Lastly, the program stimulates economic activity and job creation by reducing economic losses from drought and investing in water resources. It fosters a conducive workforce, encourages investment, and boosts economic growth in vulnerable regions.

* KyungHun Choi majored in Culture and Design Management and minored in Communication at Underwood International College of Yonsei university and worked as a Public Information Officer under the United Nations Mission in South Sudan.
* Jiyeon Park holds a BA in International Relations and a Master's degree in Urban Planning, Jiyeon Park currently works as a Programme Analyst at the UNDP and the Office of the Special Coordinator for Development in the Sahel in Senegal.
* Hanna Choi is an International Studies graduate with experience as a Project Development Intern at the UN International Organisation for Migration and as a Research Assistant for a member of the UN Human Rights Council Advisory Committee.

1. INTRODUCTION

The global water sector is currently navigating a critical phase, with escalating challenges posed by climate change and population growth reshaping its landscape.[1] This shift presents both significant challenges and emerging opportunities. Understanding and addressing these dynamics is crucial, as water scarcity is becoming an increasingly prevalent issue in many regions. In the introduction, this report delves into the current and future trends of drought and explores the concept of green growth.

1.1. Global Trends in the Water Sector

The findings of the Water Stress Index from the World Resources Institute play a pivotal role in this analysis.[2] Over the last four decades, the Index has captured an alarming global trend of increasing water stress, influenced significantly by environmental shifts and heightened demands for water resources. The current state of global water stress, as depicted through detailed infographics in this report, highlights the urgent need for innovative solutions to managing water resources. The infographics illustrate baseline water stress levels across countries, emphasizing regions with severe water-related challenges.

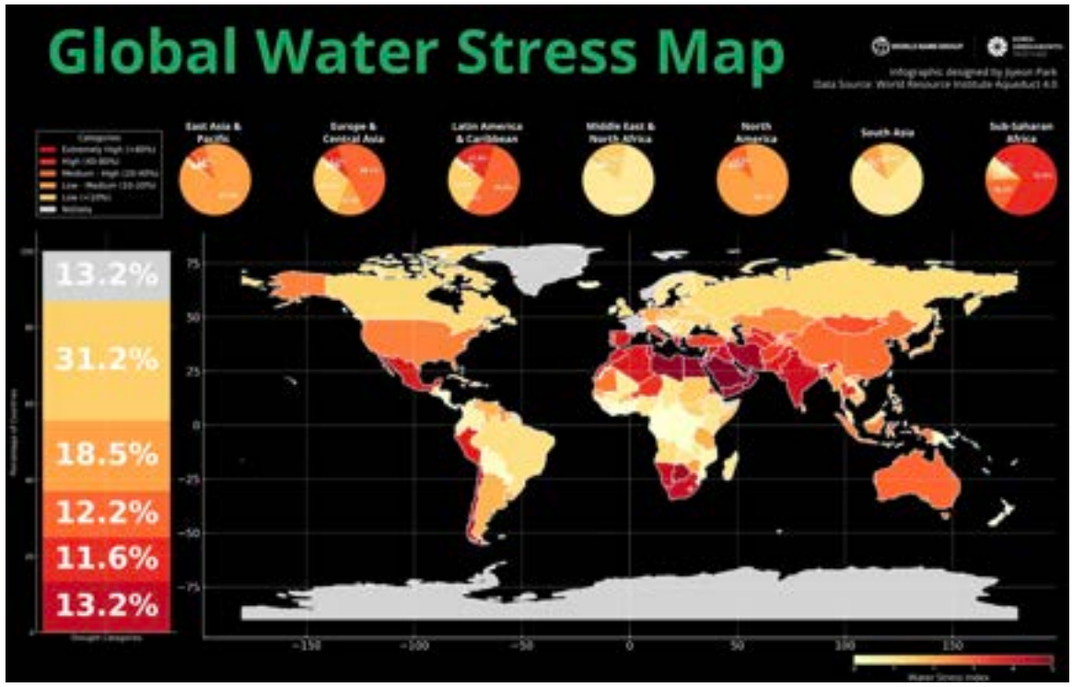

Figure 1. Global Water Stress Map

Global drought resilience currently exhibits a varied landscape, with different regions facing differing levels of water stress. Figure 1, a map of the Global Water Risk Indicator by country, alongside a bar plot, reveals the percentage of countries and their populations under varying water stress levels, from 0 to 5. The data analysis from the World Resources Institute underscores the urgency of addressing water-related challenges. It reveals that currently, 24.8% of countries experience high to extremely high levels of water stress. Particularly alarming is the situation in Sub-Saharan African countries, where 88.3% of the population is subject to high or extremely high water stress, signaling a critical need for resilient water management solutions in these areas.

1.2. Green Growth as a Key Solution

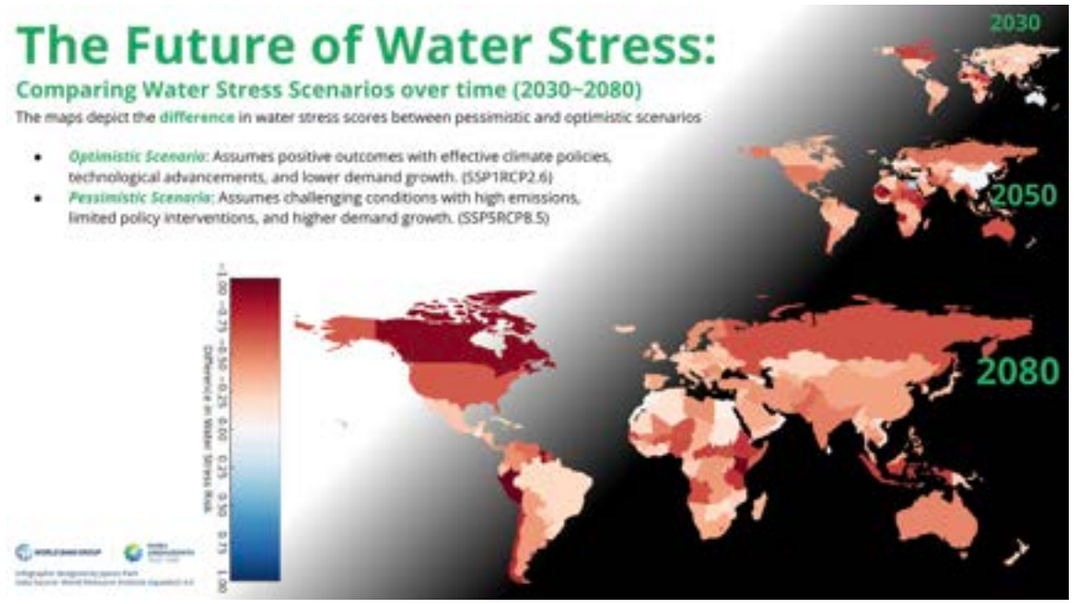

Figure 2. The Future of Water Stress

The escalating global water crisis is further emphasized by climate change. Figure 2 presents three distinct maps of the Global Water Risk Indicator under different climate change scenarios: optimistic, business as usual, and pessimistic. These maps provide a visual representation of the potential impact of climate change on water stress levels. They illustrate how many countries could suffer higher or lower water stress under each scenario and identify the regions that are most susceptible to drought due to climate change.

The comparison between the optimistic and pessimistic climate change scenarios in the report highlights the significant difference in potential water stress outcomes. It provokes crucial considerations: How much of the global population and how many countries could avoid severe water stress by adhering to an optimistic climate pathway? The report also points out the risks associated with a growth model that overlooks environmental sustainability, potentially worsening drought conditions.

The importance of green growth is thus emphasized as a key solution. This approach advocates for environmentally and economically sustainable strategies. Effective green growth in the water sector requires accurate situational analysis, local context consideration, and technological innovation. The South Angola grant program, discussed later in the report, provides a practical example of these principles in action, demonstrating how targeted, sustainable solutions can successfully address specific water management challenges. In the following section, this report is going to elaborate on how green growth is the solution.

2. GREEN GROWTH AND WATER

2.1. Literature Review

Over the past decades, it has been clear that the growth patterns have been unsustainable and inefficient. Increases in population and income have resulted in intensification of agricultural production, yielding exacerbated agrochemical and water pollution, soil exhaustion, and salinity.[1] The environment, which is considered natural

capital, is inefficiently managed due to the open access regimes for common property providing an incentive to use it up as quickly as possible. Even the subsidies exacerbate issues of common property. For instance, subsidies for energy used in irrigation in Mexico exacerbated excessive groundwater withdrawals and the depletion of key aquifers.[3]

Green growth is based on the policy imperative to achieve a growth pattern that is efficient in its use of natural capital, minimizing environmental impacts, and resilient in natural capital.[4] Protection of the environment directly contributes to economic growth as natural capital is one of the inputs for production, and conserving the environment can yield increased inputs of natural capital and thus increase income. Not only does green growth pursue a sustainable economy, but it also contributes to improving water and air quality, enhancing the well-being of humans, which is usually not clearly captured in the statistics of GDP.[5]

Combining the definitions of water security and green growth, the concept of water and green growth emphasizes the role of water for economic development, protection of the ecosystem, and social equity.[6] Water security allows us to provide the three pillars of sustainable development. According to Tae-Wan Kim of K-Water, the water sector programs aim to address various challenges such as '[e]nvironmental challenges includ[ing] water pollution, habitat degradation, and scarcity of clean water,' '[s]ocial challenges encompass[ing] equitable access to clean water, sanitation, and public health concerns,' and [e]conomic challenges involv[ing] the efficient use of water resources, investment in water infrastructure, and promoting sustainable water management practices to reduce costs and reliance on external resources.' Water plays a pivotal role as an economic catalyst, driving economic growth through expanded industrial production, increased job opportunities, and reduced public expenditures. Moreover, water is a critical factor in maintaining, and regulating ecosystem balance and freshwater contributes to healthier ecosystems. Water is also crucial for sustaining human life and public health.

2.2. Best Practices of Green Growth in Water Sector by the Republic of Korea

Water sector initiatives aimed at fostering green growth present complexities due to the need to address multifaceted challenges. "Effectively managing and navigating the broad scope of cross-sectional challenges in water programs involves strategies such as engaging diverse stakeholders, implementing integrated water resource management practices, utilizing data-driven decision-making, establishing adaptive governance structures, promoting capacity building, and embracing resource efficiency and innovation. By incorporating these strategies, water programs can address environmental, social, and economic challenges in a holistic and sustainable manner", as highlighted by Tae-Wan Kim of K-Water. In this context, the Republic of Korea (ROK) has demonstrated notable dedication towards water-related green growth practices.

Post-World War 2 Reforestation

The Food and Agriculture Organization of the United Nations (FAO) stated, "Korea is the only developing country in the world that has succeeded in reforestation since World War II." The 10-year strategic plan of the ROK government resulted in positive effects such as improved public awareness, increased income, energy security, public benefits, and a circular economy of forest resources.[7] With cutting-edge technologies and an experience of successful reforestation, the ROK government is sharing its knowledge and technology regarding Nature-based Solutions (NBS) for developing countries. Cohen-Shacham et al. (2016) defined NbS as "actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefit."[5] While complete water security cannot be achieved only by the natural environment, nature is a cornerstone to relieve water stress in many regions. Rather than altering the natural river flow, it is more effective to preserve the original conditions and to conserve ecosystem values and functions by NBS such as afforestation.

National Drought Information Portal

The ROK government employs the National Drought Information Portal (국가가뭄정보포털), a comprehensive portal providing vital information on droughts.[8] This system not only anticipates droughts in advance but also disseminates pertinent information to the public, experts, and relevant authorities, enabling informed decision-making. Users can assess their vulnerability to water shortages during droughts through real-time data on water sources. The system, consisting of seven main menus, caters to decision-makers, public officials, and experts, offering easily accessible information on drought education, response measures, and more. The portal provides localized drought information utilizing GIS map, including rainfall, water sources, past histories, forecasts, and water shortage details. Furthermore, the system incorporates advanced features such as drought surveillance, forecasting, and statistical analysis, facilitating a systematic approach to drought measures and responses. In addition, the ROK government utilizes Satellite Geography Analysis and Digital Twin technology nationwide to detect and address desertification effectively.[9]

International Collaborations

ROK - Republic of Kazakhstan

The governments of ROK and the Republic of Kazakhstan reached an agreement for forest cooperation to tackle the desiccation of the Aral Sea area that caused various problems accompanying environmental refugees.[6] The Korean ODA focused on afforestation by generating green areas rather than altering dams and other irrigation facilities. The afforestation took 15 years to show significant soil improvement. Compared to natural vegetation, which took 47 years for the same effect in the area, it was a rapid recovery of the ecosystem with the conservation of the original environment.

ROK - People's Republic of China

In the arid and semiarid regions of northern and northwestern China, the presence of deserts, including the Gobi, Taklamakan, and Kubuqi Deserts, contributes to the Yellow Dust issue.[6, 7] This phenomenon, driven by seasonal winds carrying sand, has adversely affected health, agriculture, and industry in China and neighboring countries. Human activities like logging and overgrazing have exacerbated desertification since the 1950s. To combat this, the Korea-China Amity Great Green Wall Program, initiated in 2006, focuses on afforestation in the Kubuqi Desert. Future Forest, a Korean NGO, leads the program with support from the ROK government, deploying private volunteer groups and financial backing from various Korean entities. By the end of 2019, the program had planted about 12 million trees, creating a green wall to prevent further desert expansion toward Beijing. Monitoring efforts show improvements in vegetation cover, soil stability, physicochemical soil properties, biodiversity, and carbon sequestration, indicating positive ecological impacts.

The Korea-China Amity Great Green Wall Program has not only shown environmental improvements but also contributed to socio-economic benefits. Residents near the Kubuqi Desert reported enhanced air quality and perceived afforestation as crucial for environmental improvement and economic benefits. The program also generated job opportunities for locals, reversing the rural decline caused by industrialization and urbanization. Through their participation, residents, gained afforestation skills and expressed satisfaction with the program. Survey results indicate a high level of trust among residents in the effectiveness of afforestation techniques and a willingness to continue managing the program after foreign assistance concludes in 2041. Overall, the program demonstrates a successful collaboration between Korea and China in addressing desertification, with positive outcomes for both the environment and local communities.

ROK - Mongolia

In Mongolia, the challenges of erratic and severe winters, exacerbated by global climate change, are compounded by over 40% of the country being categorized as desert or steppe, with about 90% at risk of desertification.[6, 7] Rural inhabitants, dependent on livestock husbandry, face livelihood losses due to extreme weather conditions and land devastation. The Green Asia Network (GAN), an international NGO headquartered in Korea, initiated a program in 2000, supported by the Korean government, to address desertification and Yellow Dust issues in Mongolia. GAN's Sustainable Regional Development Model (SRDM) emphasizes holistic approaches, combining environmental, societal, and economic elements, with the goal of establishing community sustainability and self-reliance. Afforestation efforts, education and training, and community engagement contribute to improved vegetation, soil fertility, and reduced local dust storms. The socio-economic benefits from the program include job creation, income diversification, and enhanced community resilience.

The Korea-Mongolia Greenbelt Plantation Program, led by the Korea Forest Service (KFS) from 2007 to 2016, aimed to combat desertification and mitigate the impact of dust and sandstorms in Mongolia. This program involved afforestation, education and training, expert dispatch, and joint research between Korea and Mongolia. Through tree nurseries and afforestation efforts, the program successfully established forest windbreaks covering about 3,000 hectares, contributing to reduced greenhouse gas emissions and improved air quality. Infrastructure development, education, and training programs enhanced the capacity of local communities, enabling them to combat deforestation and mitigate the impacts of the Yellow Dust. Resilience analysis of the program showed positive outcomes, including public participation in tree planting, technology transfer, and recognized benefits for improving livelihoods of its residents through job creation and income generation. Overall, these initiatives demonstrate the potential of international collaboration and sustainable practices in addressing desertification and fostering environmental resilience.

3. GRANT CASE STUDY: WATER SECURITY AND DROUGHT RESILIENCE IN THE SOUTH OF ANGOLA

3.1. Summary of the Grant

The grant program jointly funded and implemented with the World Bank Group, Korea Green Growth Trust Fund (KGGTF), and Global Water and Sanitation Partnership (GWSP) addresses the urgent need for a proactive and resilient approach to drought and water insecurity in the South of Angola. Focusing on the devastating drought from 2012 to 2020, it identifies four main causes of vulnerability: lack of information, insufficient investments, inefficient infrastructure mechanisms, and limited institutional capacity. The study emphasizes the importance of a comprehensive spatial view to prioritize interventions and presents a data-based approach using satellite and census data to identify vulnerable communes.

The program proposes a framework for community-level interventions in southern Angola, emphasizing hydrologic, geomorphology, and hydrogeology information. It prioritizes surface water harvesting and sand dams based on regional assessments in Cunene and Namibe provinces. The study advocates for exploring groundwater potential but highlights the need for systematic data collection and confirms that medium to deep groundwater may have limited long-term potential.

In addition, the study suggests investing in information and knowledge, community-level infrastructure, redundancy planning, and institutional capacity building. It recommends strengthening water point monitoring, implementing an integrated program for sustainable water resources, planning with regional strategic views, and investing in people and institutions. The importance of government institutions' capacity building is underscored to gather and manage relevant information and ensure financial resilience.

While estimating that USD 200 million could address drought challenges, the report emphasizes that the key obstacle is maintaining and operating infrastructure. It stresses the importance of systems and institutions fitting their operational mandates, with staff capacity to serve the population and be held accountable.

The outcome of the program acknowledges the significance of good data and builds on past government investments in data collection. It emphasizes the need for continued policy dialogue, including systematic monitoring of water points, deeper analysis of community-based management, increased accessibility of hydrogeologic information, and ongoing contributions to capacity building.

It concludes as a steppingstone, emphasizing the need for sustained collaboration with the Government of Angola. Future steps include further analysis of water point monitoring mechanisms, strengthening community-based management, increasing hydrogeologic information availability, mapping agriculture, and continuous capacity building.

3.2. Background and Objective

Angola, one of the countries prone to severe drought, continues to provide improved access to water and sanitation. Approximately 62 percent of Angola's population have access to drinkable water from an improved source and 70 percent to an improved sanitation facility.[10] Despite the improved quality and facilities, there seems to be a vast inequality of access to water and sanitation between the context of (1) the urban and rural and (2) the rich and the poor. In urban areas, access to drinking water is about 70 percent, and sanitation is 90 percent, whereas in rural areas, it averages under 37 percent for drinkable water and 27 percent for sanitation. In terms of wealth level, about 30 percent of the population in the median wealth level has water access, while the percentage drops to 15 for the poorer population. Similar trends have shown for sanitation access as, 33 percent for the middle wealth level population and 9 percent for the poorest. Despite the effort, the improvement in drinking water coverage has been impeded due to the practice of open defecation (by nearly 6 million population), population growth, and rural-to-urban migration. Children under five are the most vulnerable due to the lack of access to water and sanitation.[7] The leading cause of death remains to be diarrheal disease, which is caused by bacterial infection from contaminated water. The effect can be shown in children's growth, with the rate of stunting peaking above 40 percent.

The rural southern provinces of Benguela, Namibe, Huila, Cunene, and Cuando Cubango exhibit notable disparities in the access of water services, highlighting the challenges of impoverished communities in the rural areas. The diverse landscapes of the region range from high elevation plateaus to deserts, posing unique challenges. Improved infrastructure exists, primarily connecting the provincial capitals. The local economy relies on pastoralism, seasonal agriculture, and coastal fishing.

The South of Angola experienced a prolonged and severe drought from the weak rainy season in 2012 and 2013 until the onset of the 2019 rainy season, significantly impacting provinces such as Cunene, Namibe, and Huíla, as well as parts of Benguela and Cuando Cubango. Despite sporadic rains, the drought persisted, reaching its peak severity in 2015 and 2016, attributed to the El Niño effect. Between 2013 and 2016, 1,139,064 people, which makes up 76 to 94 percent of populations in Namibe, Cunene, and Cuando Cubango were affected, according to a Post-Disaster Needs Assessment (PDNA) supervised by the United Nations Development Programme (UNDP).

The economic impacts, exceeding USD 749 million in the three most affected provinces, were predominantly felt in the agriculture, livestock, and fisheries sector. Non-monetizable consequences included a rise in malnutrition, family abandonment, domestic violence, charcoal production, and deforestation. The PDNA highlighted that around 80 percent of boreholes were non-functional in 2016 due to water scarcity and disrepair. The drought in the region is likely to be exacerbated by the increased frequency and magnitude of droughts and floods due to global warming.[10]

3.3. Process and Methodology

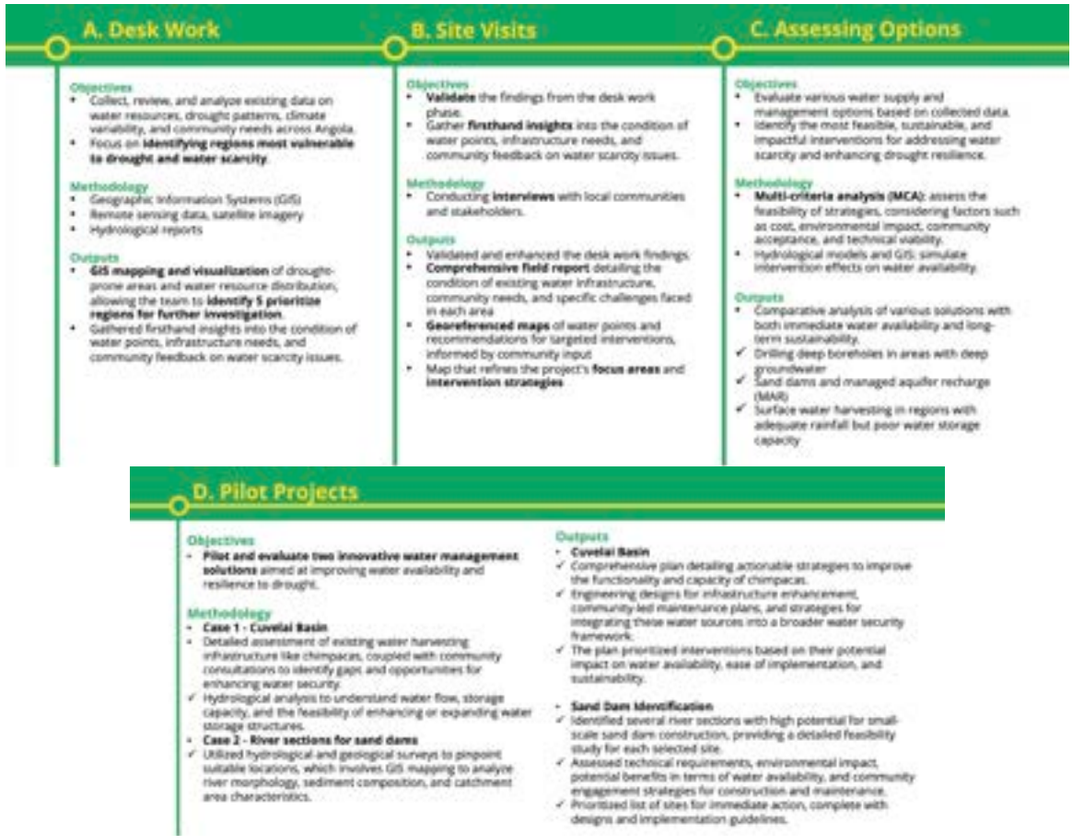

Figure 3. Project Flowchart

3.4. Results and Limitations

According to the final report of "Water Security and Drought Resilience in the South of Angola", the program takes a comprehensive approach to evaluating drought vulnerability in five provinces in the South of Angola.[10] The methodology involves analyzing census data at the commune level (INE 2014), incorporating input from partners and government agencies, and incorporating field observations from various missions.

Regional Vulnerability Mapping and Prioritization

The regional vulnerability mapping and prioritization for the 130 communes in the five provinces based on structural water access conditions have been provided through the study. A list of communes ranked by decreasing vulnerability, particularly in terms of water access, is organized by analyzing the population density. Notably affected communes include: (Benguela province) Kapupa, Wyjagombe, Lambala, Passe, Cayavi; (Namibe province) Lucira, Camacuio, Caitou, Chinquite, Cahinde, and Chingo ; (Huíla province) Tchipungo, Chimbemba, Chiange, Kapunda Kavilongo, Jau, Kusse, Cutenda, Uaba, Kalukembe, and Kalepi; (Cunene province) Mongua, Evale, Kafima, Ombala yo Mungu, Humbe, Mukope, Oximolo, Shiede, Naulila, Onkokwa, and Otchinjau; (Cuando Cubango province) Kutuile, Neriquinha, Luengue, Rivungo, Kuito Kuanavale.

Dynamics of Water Availability

The application of the DEPI drought index to the TMPA monthly precipitation confirms that the five provinces suffered moderately to severely due to the meteorological drought from 2012 to 2019. The outcome of the study indicates that the central part of the region is experiencing a more severe and prolonged drought. This region includes the provinces of Huíla and Cunene, the western region of Cuando Cubango, the southern part of Benguela, and the eastern section of Namibe. The final list of priority areas remains very similar to the aforementioned vulnerability list.

Proposal of Water Resource Investment for Enhanced Water Security and Resilience

Considering the diverse contexts in southern Angola, the program introduces a decision framework to guide the selection of suitable investments for each community or location. The study delves into the feasibility of specific solutions, such as (1) coupled chimpaca and cistern systems in Cunene province and (2) the construction and rehabilitation of sand dams in Namibe. Solely for human consumption, larger and deeper chimpacas should be built in suitable locations with cisterns. Furthermore, the sand dams would offer more water for over 6 months for at least 500 people with 500 cows and 1,000 sheep and goats with significant water storage benefits.

4. CONTRIBUTION TO SUSTAINABLE DEVELOPMENT

4.1. Social Pillar

It is essential to have the community engaged to sustain the program, as investments require maintenance. The systematic monitoring of water points and water resources, lacking in South Angola, requires a community level of confirmation and involvement. Water Point Committees or Water and Sanitation Groups (Grupos de Agua Saneamento, GAS), community-level organizations are strengthened. The community is trained onn the protection, management, and maintenance of water points. Local stakeholders affected by the drought are involved in the selection of the best solution. Furthermore, community involvement would contribute to sustaining Water, Sanitation, and Hygiene (WASH). It will lead to combating stunting and provide a sustainable environment for the children to live in. Allowing the capacity to anticipate and prepare for droughts and other shocks at the community level can reduce the high costs of devastated livelihoods.

4.2. Environmental Pillar

The environmental aspect of the Angola program is a vital part of the World Bank's approach to sustainable development. This program emphasizes the sustainable management of water resources to address challenges in a region experiencing severe droughts and consequent water stress. Implementing technologies such as sand dams and Managed Aquifer Recharge (MAR), plays a pivotal role in conserving water in the region. These methods are characterized as Nature-based Solutions (NBS) in the sense that they mimic natural processes and enhance the existing ecosystem's ability to store water. Particularly, utilizing sand dams not only helps in water conservation but also in preventing soil erosion, a common challenge in arid regions such as South Angola. Furthermore, the focus on rehabilitating and constructing new small dams and considering MAR technology represents a commitment to use natural landscapes and topography to create sustainable water storage solutions. By prioritizing environmental sustainability in its water management strategies, the program contributes to the conservation and restoration of local ecosystems that ensure long-term environmental integrity and resilience.

4.3. Economic Pillar

Furthermore, this program contributes to the economic sustainability factor in various approaches, including reduced economic losses from drought and invigorated economic activity through capacity building and water resource investments. One of the significant economic impacts is the mitigation of economic losses associated with disruptions to water dependent industries such as agriculture, livestock, and fisheries. By strengthening drought preparedness and response mechanisms, the program may minimize the negative economic impacts. Not only does the program provide the environment for the economic driver of the region, but it also allows to diminish the non-monetizable consequences such as malnutrition, family abandonment, domestic violence, charcoal production, and deforestation. Without the water issue resolved, the workforce will not be conducive to current and future functioning as the economic activities will be jeopardized. This would eventually create a favorable environment for regional investment and economic activities, thus yielding sustainable economic growth.

Then these would lead to invigorating economic activities in the region. Having the grant program strategically focus solely on the most vulnerable region to drought allows economization on the input with greater regional implications. As several technical solutions are required for maintenance, this would create water-related jobs and skills for the region. Moreover, through the water resource investment for enhanced water security and rural infrastructure, they would offer estimates of positive economic activities.

5. UTILIZING THE ROK'S DEVELOPMENT EXPERIENCE FOR GRANT PROGRAM CHALLENGES

The Korea Green Growth Trust Fund has played a significant role in supporting water sector programs by providing innovative and sustainable growth strategies and investments to developing countries, drawing from the successful experiences of the ROK. Shyam KC, Senior Water Resources Management Specialist at the World Bank Group, has emphasized the KGGTF's contribution to one of the current water programs, the Nile Cooperation for Climate Resilience (NCCR) Program. The fundamental motivation for partnering with the KGGTF for this program was "[to] be able to learn from the experience of Korea such as K-Water (Korea Water Resources Corporation), and K-Water Academy, which they organized. Korea Development Institute Center for International Development (Government), Korea Environmental Corporation (State-owned enterprise), National Institute of Green Technology (Government). A team comprising senior government officials from Lake Victoria Basin countries participated in a Knowledge Exchange visit to Korea in June 2023, which was organized by K-Water."[9]

Liaising with public and private stakeholders in Korea, the KGGTF has proposed effective strategies for water-related programs. The NCCR Program being "a grant in the amount of USD 30 million financed by the Cooperation in International Waters in Africa Trust Fund, and runs up to November 2025, the KGGTF grant was directly linked to Component 4 [Water Quality in the Lake Victoria Sub-Basin]. The KGGTF grant enabled: the [p]reparation of Lakewide Inclusive and Integrated Environmental Sanitation Strategy and stakeholder engagement. Prioritization and demonstration of integrated environmental sanitation planning in a sample of urban agglomerations in Lake Victoria Basin namely (i) large cities (Mwanza), (ii) medium-sized cities/large towns (Entebbe); and (iii) small towns that can be clustered with other adjacent towns for service provision (Homabay). Understanding private sector engagement, job creation and sanitation technologies in Lake Victoria Basin."

5.1 Limitations of the Grant Program

Political Risks

Identifying risks in building small-scale water supply infrastructure in South Angola is crucial. The political environment, especially at higher levels, poses potential challenges, but the community-based approach minimizes political and economic influences.

Budgetary and Institutional Constraints

Budgetary and institutional limitations may hinder program success. To address this, infrastructure pilots will have enhanced monitoring and support structures. Coordinating administrative levels is a concern, and rural pilots present opportunities for improved dialogue and coherence among sectors.

Risk of Community Abandonment

Potential community abandonment post-donor exit necessitates robust stakeholder engagement and capacity building. Initiatives must start early, ensuring community ownership and sustainable operation and maintenance. Local dynamics and resource conditions will guide activities.

Community Mismanagement

Community mismanagement of water points can harm farmlands. Emphasizing community capacity building is vital. Recognizing localized conflicts and understanding agropastoral habits will inform the follow-up phase, minimizing disruptions.

Technical and Environmental Risks

Technical design risks, climate impacts, and environmental considerations are addressed. Conducting water resource studies, using geospatial tools, and planning for extreme weather conditions mitigate risks. Compliance with World Bank standards, including environmental and social factors, is integral to the program's success.

5.2 ROK's Development Experience and Innovation

The National Drought Information Portal

The importance of disseminating relevant information related to Water Resilience to stakeholders is underscored in this Grant Program Report. According to Tae-Wan Kim of K-Water,

> *"Sharing information during a water program is crucial for transparency and building trust among stakeholders like funders, government agencies, and local communities. Keeping everyone informed fosters collaboration and prevents misunderstandings. Moreover, open communication empowers local communities to play an active role in decision-making processes and contribute valuable local knowledge. This not only enhances the program's effectiveness but also ensures that the community's needs and concerns are addressed. Furthermore, information sharing allows for continuous learning and improvement by facilitating the exchange of best practices and lessons learned among program partners. It also creates a culture of accountability, where all stakeholders are held responsible for their contributions to the program's success."*

Considering the importance of information sharing, a notable example from the Republic of Korea government is the National Drought Information Portal (국가가뭄정보포털), demonstrating a comprehensive approach to drought analysis and information dissemination.

The National Drought Information Portal in Korea is structured around a thorough drought analysis process. It encompasses meteorological, agricultural, hydrological, and socio-economic perspectives, providing a holistic view of drought conditions. The system consists of three analysis modules with 17 detailed functions, emphasizing data management, drought monitoring, and drought outlook analysis.

The portal not only manages integrated drought information among agencies but also supports real-time data monitoring and outlook services for the public. With a focus on swift response and decision-making, it presents a drought big board with various analysis results. If successfully applied in Angola, Africa, this system could significantly enhance data sharing, leading to more successful outcomes in water resilience initiatives. The adaptable nature of such a comprehensive information system offers promising prospects for addressing water-related challenges in diverse geographical contexts.

Community Engagement

Effectively addressing budgetary and institutional limitations in the water resilience program necessitates robust community engagement. Engaging the local community is key to overcoming financial constraints and ensuring program success. By involving the community, the program can benefit from voluntary contributions, reducing the burden on the budget and enhancing sustainability.

A compelling example of successful community engagement is found in the Republic of Korea's afforestation initiative. Rather than implementing a top-down approach, the government encouraged voluntary participation from local communities. This not only aligned with the goal of afforestation but also proved to be a cost-effective strategy, demonstrating that active community involvement can lead to successful outcomes even with limited financial resources.

In tandem with community engagement, sharing data with all stakeholders is critical for identifying and addressing challenges. Transparency through data sharing allows everyone involved to understand the program's intricacies and pinpoint areas that require attention. This commitment to information exchange serves as the foundation for community engagement policies in the context of water resilience, paving the way for overcoming the limitations inherent in the grant program.

Innovative Technologies

Ensuring data accessibility for all stakeholders is fundamental in identifying and addressing challenges, forming the cornerstone of community engagement policies for Water Resilience in this Grant Program. To achieve comprehensive data sharing, cutting-edge technologies can be employed, such as Artificial Intelligent Drought Prediction, Geospatial Analysis with Satellite Images, and Digital Twin Technologies.

Artificial Intelligence Drought Prediction stands out as a tool used by the Republic of Korea government to combat drought-related issues. This system predicts future drought-prone regions in advance, allowing the government and stakeholders to proactively address potential problems. Additionally, technologies like geospatial analysis of satellite imagery provide real-time data on regions expected to face extreme dry conditions, facilitating timely intervention.[11]

Digital Twin Technologies, a forward-looking solution, involves replicating real-world infrastructure in a virtual space through digitization. The Republic of Korea government plans to utilize this technology until 2026. It enables simulations of water-related disasters, offering a tangible understanding of potential damages and aiding citizens and water-related agencies in proactive disaster response.[12] The incorporation of AI and digital technologies signifies a strategic approach to enhance predictive management, real-time monitoring, and integrated control of dam and river facilities, contributing to effective water resilience measures.

6. CONCLUSION

The global water sector faces increasing challenges from climate change and population growth, leading to a rise in water stress levels worldwide. This report underscores the urgent need for innovative water management solutions, particularly highlighting the severe water stress in Sub-Saharan African countries, and emphasizes green growth as a key solution, advocating for environmentally and economically sustainable strategies supported by accurate analysis, local context consideration, and technological innovation. The report also presents climate change scenarios, comparing optimistic and pessimistic outcomes, and discusses the importance of prioritizing environmental sustainability to mitigate the worsening of drought conditions.

In addition, the best practices of green growth in the water sector are highlighted, focusing on successful initiatives in the Republic of Korea. These include the Republic of Korea's strategic reforestation efforts, the use of the National Drought Information Portal for effective drought anticipation and response, and collaborative programs with China and Mongolia to combat desertification through afforestation, leading to environmental improvements and socio-economic benefits. The initiatives underscore the importance of NBS and international collaboration in addressing water stress and environmental challenges.

The Grant funded in collaboration with the World Bank Group, KGGTF, and GWSP, addresses drought and water insecurity in the South of Angola, identifying causes such as lack of information, insufficient investments, inefficient infrastructure, and limited institutional capacity. This report proposes community-level interventions, emphasizing surface water harvesting and sand dams, but underscores the need for systematic data collection, institutional capacity building, and collaboration with the Government of Angola for sustained impact in addressing the severe drought's economic and social consequences.

The grant program assesses drought vulnerability in the South of Angola, identifying priority areas through a comprehensive methodology. The results include vulnerability mapping of 130 communes, dynamics of water availability, and a proposal for water resource investments, emphasizing solutions like groundwater prioritization, managed aquifer recharge techniques, and specific interventions tailored to the unique geologic contexts of the areas.

The grant program emphasizes community engagement for sustainable water management, strengthening Water Point Committees, and involving local stakeholders in decision-making. The program's environmental pillar focuses on NBS, like sand dams, contributing to water conservation and ecosystem preservation. This report also highlights the importance of community engagement, drawing on the Republic of Korea's afforestation initiative, and underscores the role of innovative technologies, such as Artificial Intelligence Drought Prediction and Digital Twin Technologies, in enhancing data sharing and proactive water resilience measures.

Information Technologies, as exemplified by the National Drought Information Portal, play a pivotal role in addressing the challenges posed by this Grant Program. These technologies, underscored by successful implementations evident in the practices of the ROK government, contribute significantly to establishing a robust water resource system. Such a system is crucial for fostering sustainable development across social, environmental, and economic dimensions. Recognizing the potential of these technological advancements, further research and detailed exploration are essential for the effective implementation and realization of the best practices adopted by the ROK government. This includes leveraging advanced technology across diverse regions to ensure the comprehensive and sustainable management of water resources, ultimately enhancing resilience to water-related challenges.

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