CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Environmental Sciences

Department of Landscape Planning

Transformation of a closed dumpsite into a Public Park: A case study in Stung Meanchey Dumpsite, Phnom Penh, Cambodia

Diploma Thesis

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DIPLOMA THESIS ASSIGNMENT

Boramy Sina

Landscape Planning

Thesis tittle

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Objective of the thesis

This thesis aims to create a masterplan proposal for transforming an abandoned dumpsite in Phnom Penh city into a public park. Additionally, it seeks to provide valuable information and knowledge relevant to the management and strategic approach required to transform closed landfills into parks. Furthermore, it offers sustainable management strategies to revitalize degraded urban areas, which helps restore the degraded environment to a vibrant urban space that beneficial to society. This contribution is expected to be advantageous for future studies focusing on landfill management and addressing the scarcity of public and green spaces in Phnom Penh. Furthermore, public

opinion was integrated into the study through online questionnaire surveys and face-to-face interviews understand better the current issue of inadequate public spaces in Phnom Penh City. The primary question posed to the public concerns its perception of the proposal to convert the dumpsite into a public park, exploring whether it supports or opposes the project. Subsequent questions include:

- What are the usage patterns and behavior of public parks by residents of Phnom Penh city, and how satisfied or dissatisfied are they with the current provision of parks?
- What are the needs and preferences of users of public parks?
- How important is the incorporation of environmental restoration efforts to the public?
- Are they committed to contributing financially to make this project happen?

Methodology

The methodology of this study is divided into "research and design":

The research phase involves reviewing existing literature to understand the management practices associated with landfill closure and post-closure management. Two benchmark cases were reviewed to identify the best management practices and design approach to transforming a landfill into a park. Additionally, the data collection includes historical information on SMCD and an online survey to identify the public's perception of current park provision in Phnom Penh city and their opinion on the proposed project of transforming SMCD into a public park. Interviews are conducted with residents near SMCD to assess their quality of life and obtain their perception of the proposal project.

The information derived from the research phase is crucial in determining which methods, technologies, and strategies approach to design suit the site while respecting the integrity of a sustainable environment and urban planning. The findings from the survey and interview serve as an essential reference in the design phase. This information helps identify the needs and preferences of potential park users, ensuring that the design meets their expectations.

The proposed extent of the thesis

102 pages

Keywords: landfill-park transformation, Stung Mean Chey dumpsite, Phnom Penh public park, landfill cap, landfill rehabilitation

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Recommended information sources

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Declaration

I hereby declare that I have independently elaborated the diploma thesis with the topic of **"Transformation of a Closed Dumpsite into a Public Park case study, Stung Meanchey Dumpsite, Phnom Penh, Cambodia"** and that I have cited all the information sources that I used in the thesis and that are also listed at the end of the thesis in the list of used information sources.

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With my own signature, I also declare that the electronic version is identical to the printed version and the data stated in the thesis has been processed in relation to the GDPR.

In Prague date

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Boramy Sina

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Undertaking this thesis topic has been a transformative experience for me, and it would not have been possible without the support, encouragement, and guidance of the individuals around me. I am deeply thankful to my professor Doc. Peter Kumble, M.L.A., Ph.D., insightful article recommendations and invaluable feedback throughout my research. From the beginning, his patience and support were crucial to completing this journey.

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Abstract

Open dumping is a primary method of managing Municipal Solid Waste (MSW) in Cambodia. Due to the increasing MSW, the number of closed dumpsites gradually increases. The first and largest dumpsite in Phnom Penh was closed, and the subsequent one is nearly full, yet the country still needs to strive to rehabilitate or restore the environmental impact of its operation. The first dumpsite was abandoned for over a decade, leaving the surrounding community suffering from the effects of the pollution's effects.

The aim of this thesis was first to provide some historical context of waste management worldwide and second to review landfill management policies and practices in developed countries. Third, the work assessed the public and official opinion about landfill transformation. Lastly, this work provides a masterplan design proposal for transforming the Stung Meanchey dumpsite (SMCD) into a recreational park based on the case study adapted to meet the specifications of the set location.

The review of the landfill management policies found cases of landfill-park transformations. According to the questionnaires, residents of Phnom Penh think positively about developing more parks in the city. Furthermore, they will support projects transforming the SMND into a recreational park.

In conclusion, transforming landfills and dumpsites into public parks is well-suited for cities with high population densities. Phnom Penh's lack of green spaces and the availability of closed dumpsites make it an ideal candidate for landfill-to-park transformation projects.

Keywords: landfill-park transformation, Stung Mean Chey dumpsite, Phnom Penh public park, landfill cap, landfill rehabilitation

Abstrakt

Otevřené skládkování je primární metodou nakládání s komunálním pevným odpadem (MSW) v Kambodži. Vlivem narůstajícího TKO se počet uzavřených skládek postupně zvyšuje. První a největší skládka v Phnom Penhu byla uzavřena a ta následující je téměř plná, ale země se stále musí snažit o obnovu nebo obnovení dopadu svého provozu na životní prostředí. První skládka byla opuštěna více než deset let, takže okolní komunita trpěla následky znečištění.

Cílem této práce bylo zaprvé poskytnout určitý historický kontext odpadového hospodářství ve světě a zadruhé zhodnotit politiku a praxi nakládání se skládkami ve vyspělých zemích. Za třetí, práce zhodnotila veřejné a oficiální mínění o transformaci skládek. Konečně, tato práce poskytuje návrh hlavního plánu pro přeměnu skládky Stung Meanchey (SMCD) na rekreační park na základě případové studie přizpůsobené tak, aby splňovala specifikace stanoveného umístění.

Přezkoumání zásad menežmentu skládek vyhledalo případy přeměn skládek na parky. Podle dotazníků obyvatelé Phnompenhu smýšlejí pozitivně o rozvoji více parků ve městě. Dále, obyvatéle Phnompenhu by byli ochotni podpořit projekty, kterých účelem by byla transformace SMND na rekreační park.

Závěrem lze říci, že přeměna skládek na veřejné parky je vhodná pro města s vysokou hustotou obyvatelstva a nedostatkem zeleně. Nedostatek zeleně v Phnompenhu a dostupnost uzavřených skládek z něj činí ideálního kandidáta pro projekty přeměny skládek na park.

Klíčová slova: Transformace skládkového parku, skládka Stung Mean Chey, veřejný park Phnom Penh, uzávěr skládky, obnova skládky

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1. Introduction

Cities and urban areas in the developing world have faced significant challenges in managing municipal solid waste (Vimean Pheakdey et al., 2022). More population is also associated with increased waste production caused by the economy's growth, industrialization, lifestyle shift, and excessive consumption (Minghua et al., 2009) (Malinauskaite et al., 2017). From a global perspective, waste management in developing countries still needs to be improved due to a lack of infrastructure, financial limitations, inadequate technology capabilities, and unclear policy (Srivastava et al., 2015). As a result, their MSWM (Municipal Solid Waste Management) relies on open dumping, as it has a low-cost operation (Agamuthu, 2013).

Phnom Penh, the capital city of Cambodia, is one of the cities in developing countries that suffer from waste mismanagement. The city experiences an urban population growth rate of 3.15% (Phnom Penh Population 2023, n.d.). It produces nearly 3000 tons of garbage daily (Sann, 2019) with most of the waste sent directly to landfills, limitation of recycling ability in term of infrastructure and facility (Spoann et al., 2019). The poor efficiency of the 3R approach (reduce, reuse, and recycle) has shortened the life of landfills (ERIA, 2022; IETC, 2020). In recent years, the Cambodian government has made significant efforts to revamp its MSWM systems by formulating new regulations, policies, strategies, and guidelines to address the pressing waste management issue. By addressing the challenges faced by local government authorities and promoting a collaborative environment between government, policymakers, and stakeholders, Cambodia is working to establish an effective and holistic waste management system that protects its environment, economy, and society (Spoann et al., 2019; Vimean Pheakdey et al., 2022; Yagasa et al., 2020). However, the regulations and policies that govern MSWM have yet to be effectively enforced. It could be related to the absence of government incentive policies encouraging public participation in 3R and private sector involvement in enhancing waste management-related businesses (Vimean Pheakdey et al., 2022).

Currently, a program has yet to be developed to decide the end-use of dumpsites and landfills in the country. There are only guidelines prepared by Ministry of Environment Cambodia (MoE) Cambodian Education and Waste Management

Organization (COMPED) for managing closed dumpsites and landfills, which indicate technical standards to minimize the potential adverse effects on the surrounding (Ministry of Environment of Cambodia et al., 2006). There are currently three official types of landfills in the country:

1. Basic standard for non-hazardous waste (non-industrial region)
2. The sanitary landfill for non-hazardous (cities and industrial regions)
3. Hazardous landfill for only hazardous waste

Even though landfills are divided into different categories, the disposal manner is similar: disposing without complying with proper sanitation standards and poor regulation and responsibility among the staff (Singh et al., 2018). Poor management of these landfills impacts the physical environment, such as water and soil contamination and air pollution, while also serving as a breeding ground for diseases that potentially affect the health of nearby residents.

The landfills in Phnom Penh city are rapidly reaching their capacity. When it officially closed, it was usually left abandoned. Once the contaminated site is abandoned, it can adversely affect the local environment and social well-being while decreasing the aesthetic value of the land and the neighborhood area (Simis et al., 2016). According to (Ferber, 2006) land with real or perceived contamination problems in developed urban areas requires intervention to bring them back into beneficial use and the most popular end-use for closed landfills are recreation grounds and parks (Aplet & Conn, 1977). In Malaysia, the National Urban Policy has adopted a brownfield regeneration program to repurpose former landfill sites into public parks to address the shortage of urban green spaces (Simis et al., 2016).

Due to their size and the landfill's location within the urban area, the sites are seen as potential areas for redevelopment into parks. With the rapid growth of urbanization and scarcity of parks and green space in Phnom Penh city, coupled with the residents encroaching on the closed dumpsite, dumpsite transformation into a public park is a perfect candidate for this initiative. Therefore, this study selected Stung Mean Chey Dumpsite (SMDS), Cambodia's first biggest disposal site, as a case study for this landfill-park project. This project has the potential to offer a solution for mitigating environmental pollution and improving public health while also addressing the pressing issue of insufficient green spaces and parks in the city. Additionally, it

could enhance social connections and well-being while providing various economic benefits for the nearby community and the city.

The objective of this thesis is to identify suitable strategies and solutions for transforming SMCD into a public park, while also assessing public opinion regarding this proposed project.

2. Literature review

2.1 Waste Management Status in Phnom Penh

Waste management has become a significant challenge for many developing nations, including Cambodia. Beyond the slow development of impoverished urban areas, the capital of Cambodia, Phnom Penh, needs help organizing and managing waste disposal. The accumulation of unmanageable waste is due to various factors, such as low levels of waste education, insufficient infrastructure (separate trash bins), rapid population growth, increased urbanization, increased levels of affluence and consumption, and inadequate waste management practices.

In Phnom Penh alone, households produce more than 2 million tons of solid waste annually, translating into an average daily waste generation of approximately one third of a kilogram (Sahmakum Teang Tnaut, 2018b). The annual increase in solid waste presents an unexpected challenge for Cambodians, especially those who live in Phnom Penh. A report by (Singh et al., 2018) highlighted that the dissemination of information, education, and knowledge about the proper management of hazardous waste is not widely conducted in Cambodia. Despite Phnom Penh's progress toward development, its residents continue to need help understanding waste management and recycling. The arrangement and classification of waste poses another challenge for urban residents due to the need for essential equipment, such as categorized trash bins and automated trash divider machines for recycling and waste disposal facilities.

Waste management methods in Cambodia are divided into two categories (Ly Srey, 2015) (**Figure 1**):

- Waste handling by citizens: First, the materials are sorted into recyclable and tradable categories. Waste pickers are also crucial to collect recyclable and tradable waste from bins and landfills. People who are unwilling to pay for garbage pick-up services would manage their trash by burning, burying it near or behind houses, dumping it along streets or open spaces, and disposing of it in water bodies, sewage canals, or any water surface (Sahmakum Teang Tnaut, 2018b).
- Waste management employed by government institutions/local authorities: Disposal occurs primarily at dump sites and landfills. In addition to landfills, municipalities collaborate with private companies and NGOs engaged in waste management for composting and recycling programs (Sang-Arun et al., 2012).

Waste deposited on the dumpsite without sorting makes recycling impossible and speeds up landfill life. According to a municipal report, the volume of trash sent to the landfill has increased due to the expansion of waste collection services by three companies. Super-GAEA, Mizuda Group and CINTRI co, Ltd. in various zones throughout the city (Mongtoeun et al., 2023). Despite the significant number of garbage trucks that collect waste, none are equipped with automated sorting machines. This deficiency may be due to the habit of citizens mixing different types of waste or trucks, eventually combining the trash during collection.

Numerous scholars have expressed concern about it, pointing out that Cambodia's uncontrollably large waste systems are the root of the problem and advocating for an immediate solution. In addition to ensuring long-term sustainability, the plan aims to improve current waste management services, educate communities about waste management challenges, and offer a framework for advocacy and community-based trash management tips.

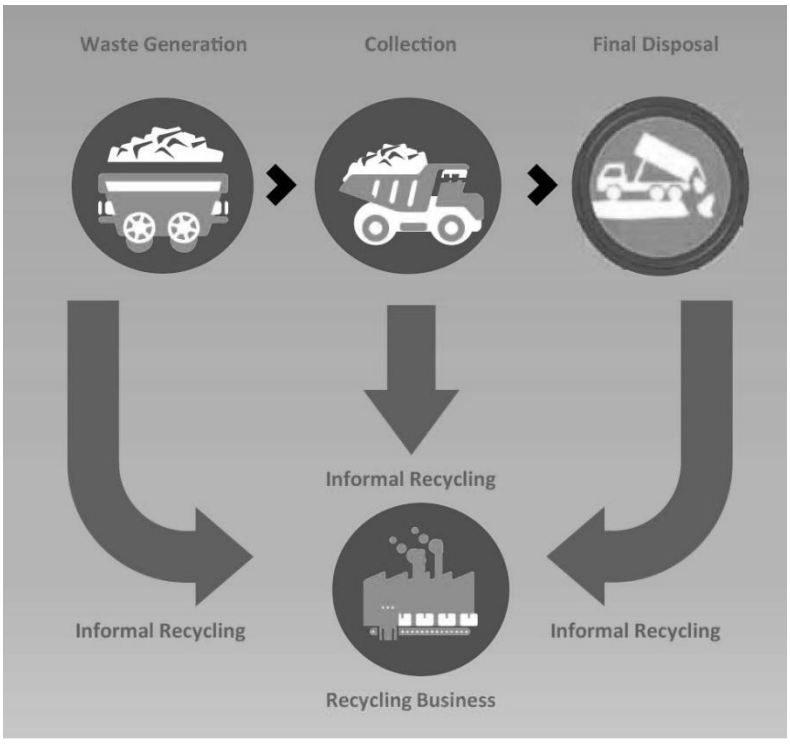


Figure 1. Municipal waste flow in Phnom Penh. Source: State of waste management Phnom Penh, Cambodia

2.2 Open Space and Public Park in Phnom Penh

The city of Phnom Penh is located at a low elevation at the junction of the Mekong Delta and Tonle Sap rivers within the great floodplain. Historically, lakes and wetlands that served as reservoirs for seasonal floods, providing livelihood to local communities through aquatic resources, tourism, and agriculture, dominated the city landscape. However, in the last two decades, Phnom Penh has undergone rapid urbanization and population growth, affecting the availability of open spaces, especially wetlands, lakes, and green spaces. Land use/land cover has been transformed from natural and semi-natural into artificial areas (Se & Katzschner, 2023). Green space has been reduced; lakes and wetlands are filled with sand to create new developments such as housing, casinos, and commercial areas. The increase in the previous surface and the influence of anthropogenic heat contribute to the urban heat island, while in the rainy season, many parts of the city are prone to urban floods.

Currently, there is no publicly available map detailing urban green spaces within Phnom Penh, making it difficult to accurately assess the extent of green spaces

in the city. According to JICA (JICA, 2014) (**Figure 2**), the provision of urban green space in Phnom Penh was approximately 1.11 km^2 per person in 2014. A survey conducted by Sahmakum Teang Tnaut (Sahmakum Teang Tnaut, 2018a) in 2018 indicated that the total area of public space in Phnom Penh was around 0.67 km^2. Furthermore, the official website of Seoul City mentioned that the total area of parks in Phnom Penh was 0.65 km^2 in 2016. Compared to neighboring cities like Ho Chi Minh, where the urban green space measures 2m^2, Bangkok provides less than 7 m^2 of public green space per capita, ranking among the lowest provisions, while the average in 22 major Asian cities is 39 m^2 per capita (United Nations, 2021). The suggestion of green space by the WHO is at least 9 m^2 per capita.

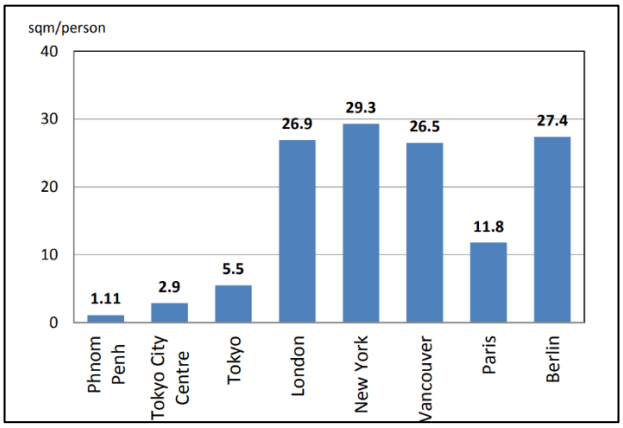


Figure 2. Comparison of the Size of Phnom Penh's Urban Green Space per Capita to Other Major Cities. Source: PPUTMP Project Team based upon the data from MLIT, Japan (JICA, 2014)

Phnom Penh has a variety of architectural styles and sculptures (**Figure 3**), but it is typically open, lacking greenery, has paved areas with limited shelter, and offers limited protection from the sun and rain (Sahmakum Teang Tnaut, 2018a). The design is not well adapted to the city's environmental and climatic conditions. These parks feature neatly mown grass, various plants, and occasionally a scattering of trees, along with the signs 'No grass trampling'. Instead of sitting directly on the grass, benches were placed along the edge of grassy areas for seating in some locations. These parks are typically located along the boulevard in the urban core (**Figure 4** & **5**). In contrast, newly constructed private residences expanding in the suburbs of Phnom Penh typically occupy all available space for housing and roads, lacking green spaces due to the absence of regulation specifying the amount of green space required for the community. On the other hand, certain private residential developments and communities have built private parks within their projects to enhance the living

standard for their residents (PHOU & SHIMA, 2022). However, those parks constitute private assets owned by individual private residential developments and are usually restricted to external visitors. The lack of public parks and the lack of access to park, projects in private communities have led to a decrease in the quality of life of suburban residents.

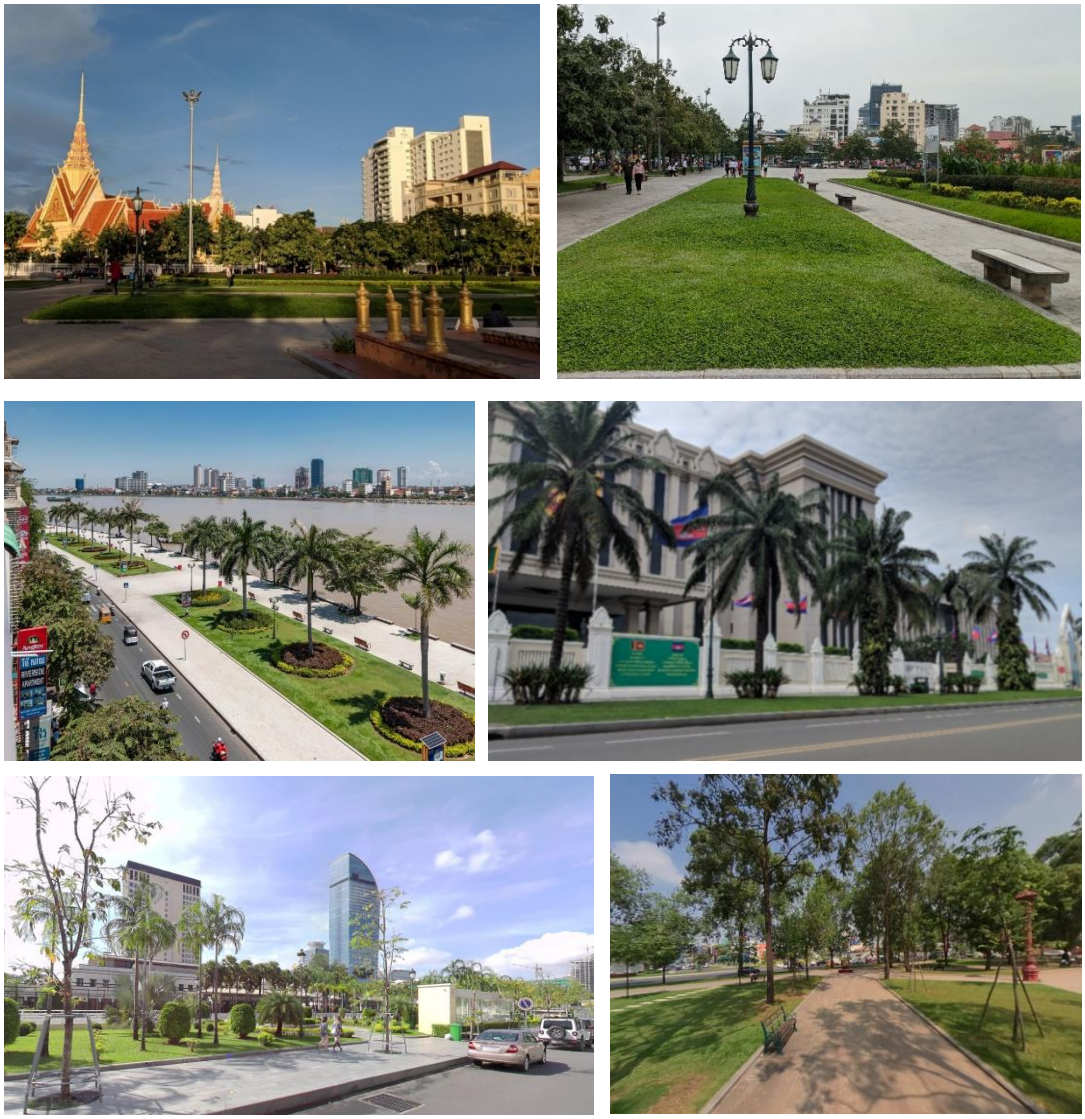


Figure 3. Architectural design and feature of public parks in Phnom Penh. Source: Author

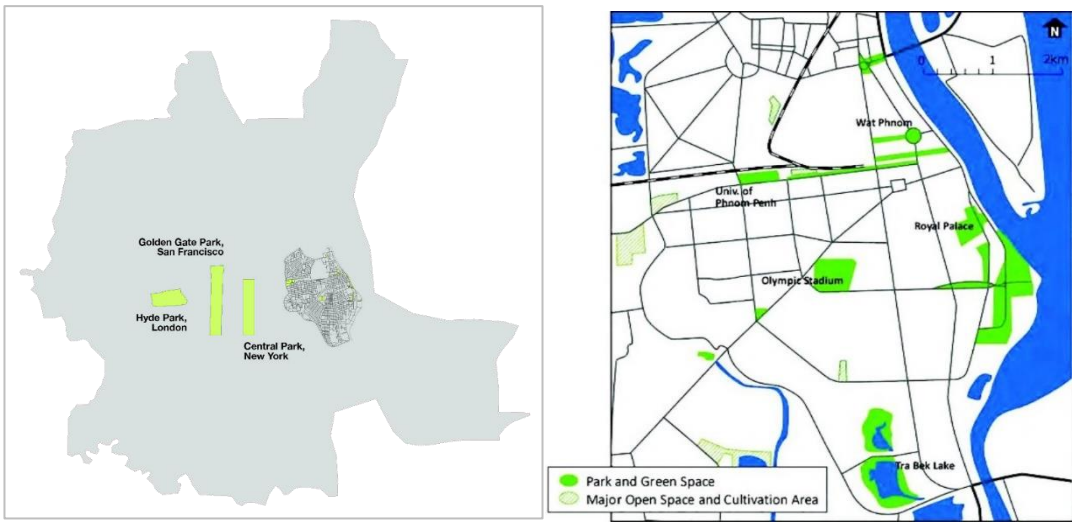


Figure 4 . Map of Urban Green Space in the Core of Phnom Penh City. Source: (JICA, 2014).

Figure 5 Size of urban green space provision in Phnom Penh city compared to Hyde Park in London, Golden Gate Park in San Francisco, and Central Park in New York. Source: cityofwater.wordpress.com/

Public and green spaces in Phnom Penh face the risk of privatization and reclassification without public discussion, mainly because there is no adequate documentation and mapping accessible to the public (Sahmakum Teang Tnaut, 2018a). This pattern reflects global concerns, as the privatization of public spaces has been condemned as the 'death of the public realm" (Németh, 2012). However, Phnom Penh residents do not understand the definition of public space and its rights to protect such areas. The 2001 Cambodian Land Law does not clearly define "Public Space." Still, it offers protection for areas commonly categorized as "State Public Property or Land" and "Collective Property or Land." The State Public Property cannot be sold unless it is reclassified as State Private Property or if it loses its public interest use. However, the term' loss of public interest" appears to be implemented without public consultation and is determined solely by government officials (Sahmakum Teang Tnaut, 2018a).

2.3 Brief history of sanitary landfill practices in Western and Asian countries

Early human societies produced waste mainly in the form of biodegradable waste that decomposed naturally. Over time, the scale and type of waste production changed, particularly in the development of agriculture and the establishment of settled communities. When cities were built, the high density of population required waste

management to minimize the spread of odors, pests, and diseases. The first trash regulations were found in Crete, where residents were prohibited from dumping trash on the streets (*First Landfill Sites*, n.d.). The earliest disposal sites also originated in Crete in 3,000 BC, where waste was deposited into a large pit and then covered with soil (Queen Mary, n.d.). On the other hand, the Romans did not have an organized waste removal system, resulting in waste accumulation in the streets and surrounding areas of towns and villages. This practice reportedly persisted until the 19th century (Wilson, 1976).

Discarding items was a final option before the Industrial Revolution and the widespread use of consumer packaging and ready-made goods. People would be repaired, repurposed, and reused until there was little left to use. Human and animal feces were used as fertilizer or burned in indoor burners and fireplaces. Food waste was fed to animals or disposed of in open water bodies such as ponds, bogs, lakes, rivers, and oceans. In cities across the United States and Europe, waste was also littered on the street or vacant land until the 1800s (Bridgwater, 1986; Powell, 2011). Consequently, these waste management practices caused sanitation problems and increased the risk of disease (Louis, 2004). With the onset of the Industrial Revolution, the urban population increased in cities in Europe and the United States, leading to a further acceleration in waste production. Between the 1870s and 1960s, the birth of waste in the form of disposables arose, meaning that it could be easily discarded (Barles, 2014). Due to the scarcity of disposal space and the increasing environmental challenges, societies are prompted to establish a waste disposal system. The innovation method for handling garbage known as 'incineration' that involves the burning of waste was found in 1874 in Nottingham, England (Jay, 2010). A cholera epidemic in 1892 precipitated the construction of the first European incinerator in Hamburg, Germany, in 1893, and this plant operated until 1942. The first incinerators in the United States were built in 1885 in Allegheny, Pennsylvania (Wilson, 1976). However, some cities in Europe and the US lacked organized facilities for street cleaning, garbage collection, water treatment, and human waste removal until the early 1800s (Louis, 2004). Recognizing the link between disease and poor sanitation caused by improper waste disposal on the streets, the practice shifted in the late 1900s to include garbage collection and disposal from the roads to open dumps, burning, or into the sea (Chetri & Reddy, 2020).

2.3.1 History of sanitary landfill practices in the United States

In 1935, the first landfilling began in California, where waste was disposed in a pit and periodically covered with layers of soil (Chetri & Reddy, 2020). The first guideline for a 'sanitary landfill' published by The American Society of Civil Engineering in 1959 involves waste compaction and daily cover with a layer of soil to minimize odor and control rodents. From 1965 to 1991, America passed and elevated many regulations and guidelines on landfill construction standards. Modern landfill regulations focus on determining suitable landfill locations and avoiding landfill construction in floodplains, wetlands, or other restricted areas (US EPA, 2016). The selected location must ensure the safety of human health and the environment while ensuring the landfill's structural integrity. Additionally, the landfill owner is required to submit a report to the state regulatory agency for any monitoring activities related to ground and surface water and air (Modern Landfills, 2006).

Landfills in the US are owned by private companies, government (local, state, or federal), or individuals. In 2004, 64% of MSW landfills were owned by public entities, and 36% were privately owned. The entities responsible in this context are mainly involved in managing landfills to dispose of nonhazardous solid waste. Their responsibilities include tasks such as the local collection and transportation of nonhazardous waste materials, as well as the operation of landfills for disposal purposes. Furthermore, government institutions involved in administrating and regulating solid waste management programs are also part of this industry (US EPA, 2016). Additionally, handling hazardous waste falls under the responsibility of the US. Environmental Protection Agency. It is important to note that the number of landfills in the United States has decreased significantly from 7,900 in 1988 to 1,269 in 2018 due to the efficiency of waste recycling and composting practices (US EPA, 2016).

2.3.2 History of sanitary landfill practices in Europe

Information about the first landfill in Europe is complex and challenging to locate precisely because of a lack of detailed records. The composition of waste changed significantly throughout the twentieth century, and both quantities and types

of waste were not recorded, as there was no requirement to keep records of waste disposal in landfill sites (Bridgwater, 1986). However, it is known that England had about 20,000 historic landfills constructed before implementing the Controlled Pollution Act (1974) and operated without any engineering for leachate control (O'Shea et al., 2018). In 1994, the Waste Management Licensing Regulation required all landfill sites to maintain the records of disposed waste. These records must include estimates of the total amounts of biodegradable, nonbiodegradable waste, along with the special waste's location, which may pollute. The introduction of the 2002 Landfill Regulation in England and Wales required more detail about the waste, including the origin, type, volume, and disposal location of the waste. Additionally, hazardous materials are prohibited from being disposed of in the same landfill (Queen Mary, n.d.). During the same period, the European Union implemented the EU landfill Directive (Directive 1999/31/EC), considered a significant milestone in EU waste policy. This directive provides guidance and procedures to prevent or alleviate environmental impacts, specifically reducing the amount of biodegradable municipal waste sent to landfills by 2016 (European Environmental Agency, 2009). The Landfill Directive is concerned about pollution of surface and groundwater, soil, and air, as well as the greenhouse effect and potential risks to human health from landfill operations (European Union, 1999). In 2009, the new landfill directive was enacted, establishing requirements for environmentally friendly landfills. It outlines the organizational structure of landfill operators, as well as specifications for personnel, financial security, and leachate and gas. Furthermore, the directive includes guidelines for the construction and monitoring of closed landfills and maintenance after closure (Lehmphul, 2014). According to Directive 2009, the old landfill must comply with standardized requirements or face closure by 16 July 2009 (European Commission, 2023).

The amount of waste generation in Europe has continued to increase; however, landfill rates have decreased from 23% to 16% between 2010 and 2020. The total amount of waste sent to landfills has markedly reduced by 27.5%, from 73 million tons to 125 million tons from 2010 to 2020 (EEA, 2024). The European Union aims to reduce the MSW landfill rate to 10% or less by 2035. Landfill practice remains prevalent in eastern and southern Europe, with Malta at>70%, Greece, Cyprus, and Romania at>50%. In contrast, Spain and Portugal have decreased the landfill rate to

less than 50% compared to 2017. Countries that have achieved almost negligible landfill rates include the Netherlands, Denmark, Sweden, Germany, Austria, Luxembourg, Slovenia, and Finland (European Parliament, 2018). Despite the EU's goal to reduce landfill rates, landfills will remain a crucial component of the waste management system beyond 2020. However, according to the waste hierarchy of the EU, landfill is considered the last management option when waste cannot be recycled (European Commission, 2023).

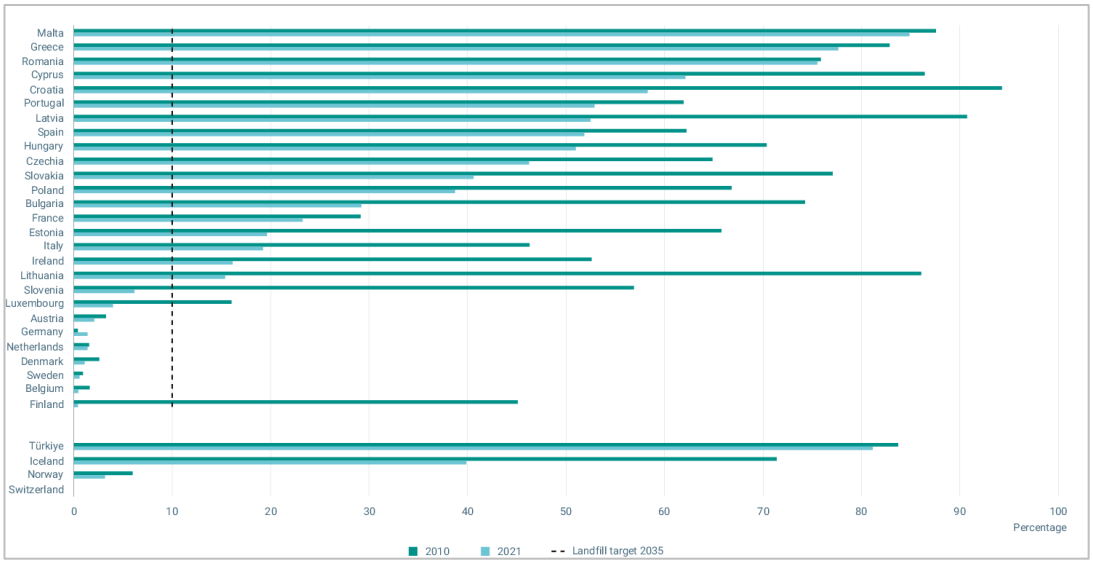


Figure 6. Municipal waste landfill rates in Europe by country. *Source: Diversion of waste from landfill in Europe (EEA, 2024)*

2.3.3 History of sanitary landfill practices in Asia

Sanitary landfill practices were introduced worldwide in the 20th century, but the timeline for adoption in Asia may vary. Implementing solid waste management in Asia has only been carried out in the last five decades (Agamuthu & Babel, 2023). Presently, waste management systems in these regions mainly rely on open dumps. This dependency can be attributed to various factors, including rapid urbanization, economic constraints, political and regulatory challenges, inadequate technologies and infrastructure, and a need for more awareness and education.

Asia, inhabited by 60% of the global population, is the world's most significant contributor to waste production (Modak & Lim, 2017). The estimated waste quantity of around 1.8 billion tonnes is projected to double by 2030 in urban areas across Asian countries, except Japan and Korea, where waste generation has

declined (Agamuthu & Babel, 2023). The technologies and challenges related to waste management in developing Asian countries are ever-changing, coupled with economic challenges, and the availability of reliable data and transparency remains a major issue compared to developed countries (Agamuthu & Babel, 2023).

Many Asian countries primarily use open dumpsites for waste disposal, with percentages as high as 79% in South Asia, 64% in Southeast Asia, and 51.1% in South and Central Asia. (Kaza et al., 2018). Within the ASEAN region (ten member countries of Southeast Asia), open dumps and sanitary dumps are common, as shown in (**Table 1**), with each member country having its waste management policies (Jain, 2017). Some ASEAN countries have significantly improved their waste management system, recycling programs, and adopting sustainable practices. Singapore is known for its efficient waste management system and advanced technology. The country firmly intends to reduce the amount of waste sent to landfill per capita per day by 30% by 2023 (Herrador & Van, 2024). Other ASEAN nations still need to overcome many challenges concerning inadequate infrastructure, population growth, and limited resources, leading to more complex waste management issues.

Table 1. MSW management method in ASEAN countries. Source: Summary report of Waste management in ASEAN countries (Jain, 2017)

Country	Treatment/disposal				
	Composting	Incineration	Sanitary landfill	Open dump	Open burning
Brunei Darussalam			✓	✓	
Cambodia	✓		✓	✓	✓
Indonesia	✓	✓	✓	✓	✓
Lao PDR	✓		✓	✓	✓
Malaysia		✓	✓	✓	
Myanmar		✓	✓	✓	
Philippines	✓		✓	✓	
Singapore		✓	✓	✓	
Thailand	✓	✓	✓	✓	
Vietnam	✓		✓	✓	

MSW: municipal solid waste.

In Vietnam, only 16 out of 98 active landfills follow proper waste management practices, Approximately 76–82% of municipal solid waste (MSW) in the country is improperly disposed of at dump sites or landfills (Truong, 2018). Cambodia has 164 privately owned and state-owned landfills throughout the country. The landfills received 2.09 million tons of MSW in 2021, which does not account for the unsafe disposal (ODC, 2023). Thailand has many open dumps, consisting of 32 privately owned and 1670 under state control. The country has 70 well-managed disposal sites, including sanitary, engineered, and semi-aerobic landfills. The country has an impressive waste collection and recycling rate of 88.8%, yet there remains an unaddressed issue, with approximately 482 Kton of plastic waste going uncollected annually (World Bank, 2022).

The main waste contributor among ASEAN countries, led by Indonesia, produces around 64 million tonnes of waste annually. The country has 521 landfill sites, and most operate as open dumps. While ASEAN has faced challenges in the waste management system, other Asian countries can learn valuable lessons from advanced nations, particularly Japan, a solid waste management sector pioneer for many decades. Japan has successfully adopted a decentralized waste management system supported by solid laws, clear roles, and collaboration among government, stakeholders, and citizens. This approach has led to significant reductions in waste generation, higher recycling rates, and minimal landfill use, with only 1% of waste being disposed of in landfill (World Bank, 2023).

In conclusion, progress in waste management has been observed in the United States, Europe, and Asia. However, each region encounters unique challenges and successes. Each region and country employ different strategies and practices, but they share a common goal of achieving a sustainable and healthy environment. The United States has made significant strides in recycling and landfill diversion, aiming to reduce disposal costs and ease the burden on landfills. However, the country still needs to grapple with high waste generation per capita. In Europe, particularly within the European Union, the region is known as a global leader in waste management. Considering the principles of a circular economy, the EU promotes waste reduction, recycling, and resource efficiency. Collaborative efforts among member nations contribute to a more cohesive and sustainable waste management framework.

On the other hand, Asia presents a diverse landscape in terms of economic development and cultural practices, leading to various challenges in waste management dynamics in countries. Some Asian nations have made significant strides by adopting innovative technologies and policies, while others are grappling with alarming crises due to waste mismanagement. However, there is potential for mutual learning between countries, as exchanging best practices and technology can improve waste management efforts, enabling a transition to a sustainable and circular economy. This collaborative approach is essential to ensure a healthy and sustainable environment for future generations.

2.4 Opportunities and barriers of redeveloping closed landfill site

Landfill sites present in almost every country serve as symbols of environmental degradation and poor waste management. However, the need for more space in urban areas has sparked interest in redeveloping former landfill sites. Several examples of common end use for landfill sites include solar energy farms, wildlife habitats, parks, green spaces, and golf courses. In New Zealand, especially in urban regions, closed landfills have been repurposed into open public spaces for recreational use. At the same time, rural areas are transformed for agricultural purposes, specifically for grazing (New Zealand, 2001). According to an article by (Misgav et al., 2001), there is a variable rate of success in redeveloping landfills for different purposes in the UK. Success rates vary, with natural generation achieving up to 41%, amenity trees and sports / leisure facilities showing a success rate of 54%-55%, and other soft uses achieving a higher success rate of 75-79%. However, attempts at hard uses, especially housing, have not been very successful, with the lowest success rate of 33%.

One of the most popular practices for repurposing closed landfill sites is to transform them into parks. It is not coincidental that many countries choose to redevelop full landfill sites into such projects due to their large size and proximity to urban settlements. Another reason involves the decline of green spaces in cities and urban areas, coupled with the increased waste generation resulting from rapid urbanization. Harnik, Taylor, and Welle (Harnik et al., 2006) stated that around 250 recreational sites have been built on former landfill sites. There are a few well-known

examples of landfill park projects that have already welcomed visitors such as Freshkills Park in New York, Nanjido Ecological Park in Korea, Ariel Sharon Park in Tel Aviv, Semakau Eco Park in Singapore, and Port Sunlight River Park in Liverpool. These landfill park projects are considered successful implementations, providing evidence of improved ecosystems and the integration of biodiversity (Bardos & Cundy, 2017; Lawson, 2015; Seoul Metropolitan Government, 2015). The strategic framework, technology adoption, and outcomes of these landfill park projects are described in chapter: III.

In the context of rapid urbanization, the landfill park project presents significant opportunities and benefits, including:

- Environmental Restoration: clean up pollution from the contaminated land to mitigate environmental risks and hazards and reduce the number of landfills.
- Establishing Green Spaces: offering recreational and leisure opportunities for the community and promoting physical activities and well-being
- Community Engagement: Provide communal space for gathering and promoting social cohesion.
- Economic Benefits: Increase surrounding property values and attract visitors, which in turn helps create job opportunities.
- Educational Opportunities: the place for raising awareness regarding environmental issues and promoting waste recycling and reduction.

Despite the benefits, there are several potential challenges when attempting to redevelop landfills, including:

- Site Contamination: Open dumps or old landfill sites are often not engineered or included in the environmental protection measure. Sites contain toxic waste that contaminated soil and groundwater. The degradation of waste releases methane gas, contributing to air pollution and leachate leakage into water bodies.
- Lack of data and Monitoring: Inadequate information about the operational history, a lack of transparency in waste composition and quantity records, and unclear responsibilities of former operators pose significant challenges in obtaining solid data.
- Technological Constraints: Developing countries often face challenges due to

insufficient infrastructure, technological issues associated with landfill remediation processes, and a lack of experience to participate in such projects.

- Public Perception: Concern about the health risks and safety associated with waste contamination.
- Funding: The lack of financial resources to implement the project, coupled with the prioritization of other issues by the government on the redevelopment of former landfill sites, presents a major obstacle.
- Political and legal compliance: Redevelopment projects must follow the country's regulations and policies of the country related to environmental protection and land use. Meeting all standards and regulations can be a complex and time-consuming process.

2.5 Guidelines of transforming closed landfills into park

The operation of dump sites poses a significant hazard to the environment. Despite this, many developing countries rely heavily on open dumps as their primary waste management method. The manner of operation of dumpsites contributes to environmental degradation and exacerbates global warming. A question arises: How can these defective lands be revived? The answer is yes, but it is a complex undertaking that requires careful consideration of various factors. These include the site's background, location, environmental impact assessment, climate condition, and the stakeholders' interests (Gerth et al., 2016).

Firstly, proper closure management is required at existing or abandoned MSW disposal sites to mitigate environmental pollution, which includes leachate contamination, methane gas emissions, waste burning, collapse due to instability, public health risks, and other associated socio-economic issues (Anurudda et al., 2021). It is important to note that there are differences between the closure and landfill closure. The former is more complex because the site is not engineered. Thus, the initial practice for this type of dump is to improve the site condition through rehabilitation to minimize hazard risk (Anurudda et al., 2021). This involves the following:

- Implement appropriate technologies to mitigate all types of risks associated with waste decomposition.

- Establish suitable operation and maintenance procedures to ensure the sustainability of technical improvement measures.
- Creating a monitoring and correction mechanism to verify the effectiveness of technical improvement measures.
- Developing a closure and post-closure management plan for long-term maintenance and monitoring.

2.5.1 Final Cover (Final Cap)

The final cap marks the end of the use of the dump site or landfill. Once the landfill is capped, the site becomes suitable for conversion into parks or recreational facilities. Several important factors to consider during this phase are the landfill bottom liner and the landfill collection system. If the bottom effectively prevents seepage and the leachate collection system is active in place, natural soil can be used for the final cap. According to U.S. final cover guidelines, a minimum 18-inch earthen infiltration layer topped with a 6-inch erosion layer is mandated to support native plants' growth. Alternative cover designs are permissible if they offer comparable protection against infiltration and erosion (US EPA, 2016). The final cap design can be altered to suit site-specific requirements, provided that the effectiveness of the alternative design is proven. A final recommended cap in New Zealand typically comprises a 150mm layer of topsoil for vegetation, a 600mm compacted barrier layer (composed of silt, silty clay, and clay with a permeability coefficient of $\leq 1 \times 10\text{-}7$ m/s), and a 300 mm compacted subgrade or foundation layer. Depending on the situation, thicker layers might be necessary and a subsoil layer could be placed between the barrier and topsoil layers (New Zealand, 2001).

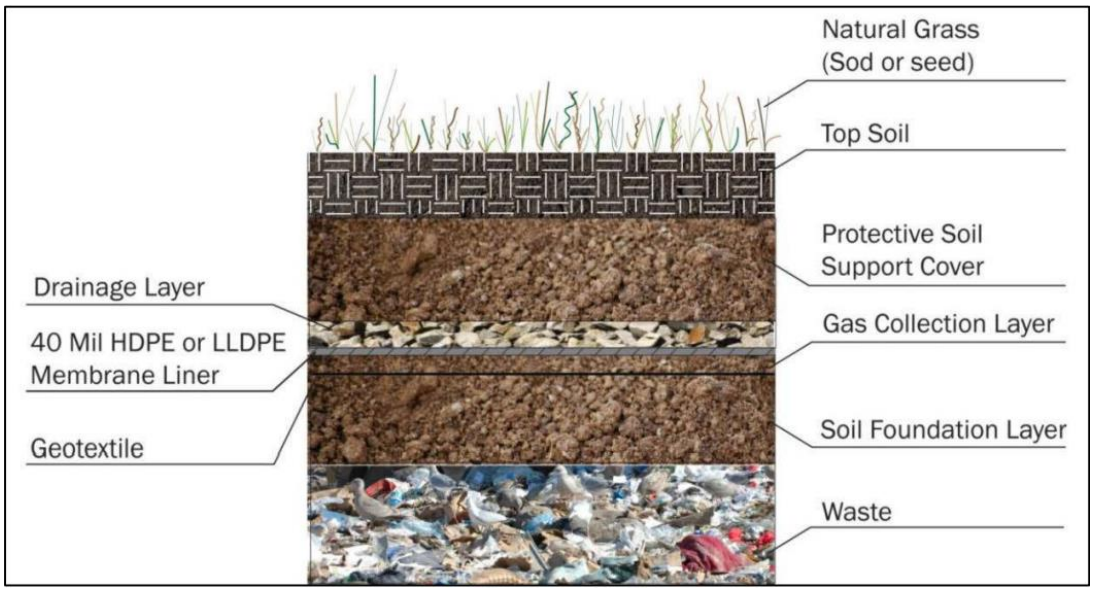


Figure 7. A detail of a traditional landfill cap used for MSW landfills. Source: www.scsengineers.com

2.5.2 Post closure

Post-closure care involves the maintenance and monitoring of the landfill. Maintenance ensures that waste is appropriately managed while monitoring prevents potential risks from polluting the surrounding environment. In many states in the USA, landfill owners are mandated to set aside funds for 30-40 years of long-term care (Bagchi & Bhattacharya, 2015). Similarly, in New Zealand, providing at least a 30-year period of post-closure care is recommended. The duration of maintenance and monitoring can be adjusted based on the findings of periodic monitoring by the director of an approved state program in the USA and New Zealand, which a regional council must approve. Specific post-closure tasks should include:

- Maintaining the integrity and effectiveness of annual tasks such as storm water drains.
- Cleaning leachate collection pipes.
- Managing vegetation.

Monitoring should cover groundwater and surface water quality, leachate and landfill gas, the condition of the final cap, and vegetation cover (New Zealand, 2001; US EPA, 2016). It is essential to note that the redevelopment of landfills into park projects may involve implementing silvicultural, agricultural, ecological, and engineering practices to ensure its successful implementation (Environmental Protection Agency, 1995).

2.6 The role and benefit of urban green space in the city

Most urban planners in cities aim to create livable and lively urban environments. However, achieving this goal becomes challenging as the urban population grows and space becomes limited. Urban growth leads to a need for more public spaces and places a high demand on natural resources. Consequently, redeveloping landfills and repurposing them for beneficial use becomes crucial. Although redeveloping landfill sites may seem complex compared to developing greenfield areas, many cities in Europe, the US, and some Asian countries have successfully implemented such transformations due to space constraints. Before considering the redevelopment of closed landfills for recreational purposes, it is essential to emphasize the benefits of open spaces and publicly accessible urban parks. According to the WHO, urban green space covers areas with ‘natural surfaces’ or ‘natural settings’; it can also include different urban greenery such as street trees or ‘blue space’ representing various water features, from ponds to coastal zones. These spaces in urban settings include parks, private gardens, forests, children’s play areas, non-amenity areas, riverside footpaths, beaches, etc. (Thompson et al., 2016). Urban green space is a critical component of "green infrastructure serving as a vital part of a city's open space and communal services. It is essential to ensure easy access for all demographic groups and that they are distributed fairly throughout the city (WHO, 2017). Accessible and high-quality urban green spaces, such as parks, urban forests, tree lined streets, and allotments (EEA Report, 2020), offer extensive benefits for physical and mental health for individuals and neighboring communities (Jansson, 2014) and ensure the protection of key ecosystem services, including climate regulation, carbon reduction carbon sequestration, and rainwater drainage (Orsi, 2018).

2.6.1 Environmental benefits

Urban green spaces offer valuable environmental benefits. They contribute significantly to promoting ecological sustainability by acting as carbon sinks, reducing the effect of urban heat islands, fostering biodiversity, and providing a habitat for wildlife (Haq, 2011). The evolving nature of our cities generates an urban heat island effect caused by reduced vegetation, increased levels of gray and impermeable

surfaces, and the production of anthropogenic heat (Mohajerani et al., 2017; Stone et al., 2010). A recent study has disclosed that the urban heat island can increase air temperatures by 5 to 15°C higher than in its rural surroundings(Joint Research Centre, 2022; Mohajerani et al., 2017). Urban tree canopies have the potential to decrease surface temperatures by 10-20°C on a summer day. The effect on air temperatures is slightly less when a row of urban trees is planted along the streets; on average, they can reduce summer-time air temperature by 0.5-2°C. Meanwhile, more enormous forests in parks can have a more significant effect, lowering peak air temperatures downwind by up to 5 °C (Mcdonald et al., 2020). Urban green spaces such as forests, parks, green spaces or other vegetated areas can absorb carbon dioxide (Strohbach et al., 2012), help combat climate change, improve air quality by filtering pollution, and create an 'urban cool island' effect (Diener & Mudu, 2021; Zhou & Rana, 2012).

2.6.2 Health benefits

Urban green spaces provide both explicit and implicit benefits to citizens. Many studies have revealed the benefits of urban green space linked to improved health. For centuries, it has been widely recognized that contact with nature improves mental health. The concept of 'biophilia' highlighted that humans are inseparable from nature (Zhou & Rana, 2012). Psychophysiological stress reduction theory suggests that contact with the natural setting can benefit those who experience high stress levels (Corazon et al., 2019) , and reduce rates of depression and anxiety, and reduce cortisol levels resulting in enhanced well-being and relaxation (Park et al., 2010; Wells & Evans, 2003). According to WHO (WHO, 2017), urban green space also improves physical fitness and cognitive and immune function while reducing overall mortality rates. Many experimental studies have reported that short-term exposure to green spaces like parks, urban forests, and forests, has a positive impact on mood and attention and recovery from physical stress (Song et al., 2024).

2.6.3 Social benefits

Urban green space also plays an important role in social interaction and in the promotion of a sense of community (Kim & Kaplan, 2004; Zhou & Rana, 2012). The sense of community refers to social cohesion associated with solidarity between the

community and the extent of connectedness, a feeling of trust, belonging, and acceptance (Jennings & Bamkole, 2019; Manca, 2014). Therefore, urban green space decreases social isolation and improves personal resilience and well-being (Lee et al., 2015), especially for older people, as they predominantly suffer from loneliness. A study conducted in Helsinki, Finland, showed that 97% of city residents engage in outdoor recreation annually, half participating daily or every other day. However, Chapultepec Park receives up to three million weekly visitors for various recreational activities (Haq, 2011). Green space may also benefit children's cognition (Fernandes et al., 2023). Children who live in areas with more green spaces have a better spatial working memory. Exposure to outdoor greenery appears to impact the cognitive development of primary school children positively. Furthermore, students who can view green landscapes from the classroom significantly improve attention, test performance, and recovery from stressful experiences (Russo & Andreucci, 2023).

2.6.4 Economic benefits

Despite the environmental, health, and social benefits, urban green space contributes to economic benefits by providing a cooling effect. Trees and vegetation help lower surface temperatures, provide shade, and release moisture into the atmosphere, ultimately reducing energy costs. Based on a study in Chicago, it was highlighted that having a 10% tree cover in the city may reduce the total energy expenditure for heating and cooling by 5 to 10% (Haq, 2011). Alongside the benefits mentioned above, green space also contributes to housing prices. Recent studies have shown that residents near green spaces or parks positively impact housing prices and are usually more desirable and expensive (Chen et al., 2023). According to (Chen et al., 2023), the residents of the UK have expressed a willingness to pay extra amounts to reside near urban parks. Likewise, in Finland, residents are willing to pay 4.9% extra to live near natural green areas. The nature of green space is a factor in a desirable neighborhood.

In conclusion, pursuing vibrant and livable urban environments is a formidable challenge for urban planners as the city population grows and the space is constrained. Redeveloping closed landfills for recreation is crucial to address the shortage of urban green space. Although cities appear preferable for most of the

world’s population, providing green space within urban areas is a key component of sustainable urban development. Urban planners should consider redeveloping a refused landfill into green space to revive the benefits of contaminated land. At the same time, urban green spaces promote the well-being and social cohesion of civilians, enrich environmental and ecological systems, and contribute to the economic vitality of cities.

3. Methodology

This study is divided into two fundamental components: “research and design” (**Figure 8**) The research part is key to offering valuable insight into users’ needs and preferences, functioning as a decision-making tool for this project. This part of the research is based on sources from primary and secondary data. Primary data include interviews, observation, and case studies from successful Landfill-Park projects. Secondary data involve a review of the literature using the findings resulting from the literature to analyze the theories and practice of landfill-park transformation. The design component, in turn, relies on the information derived from the research phase to propose a master plan for the SMCD landfill-park.

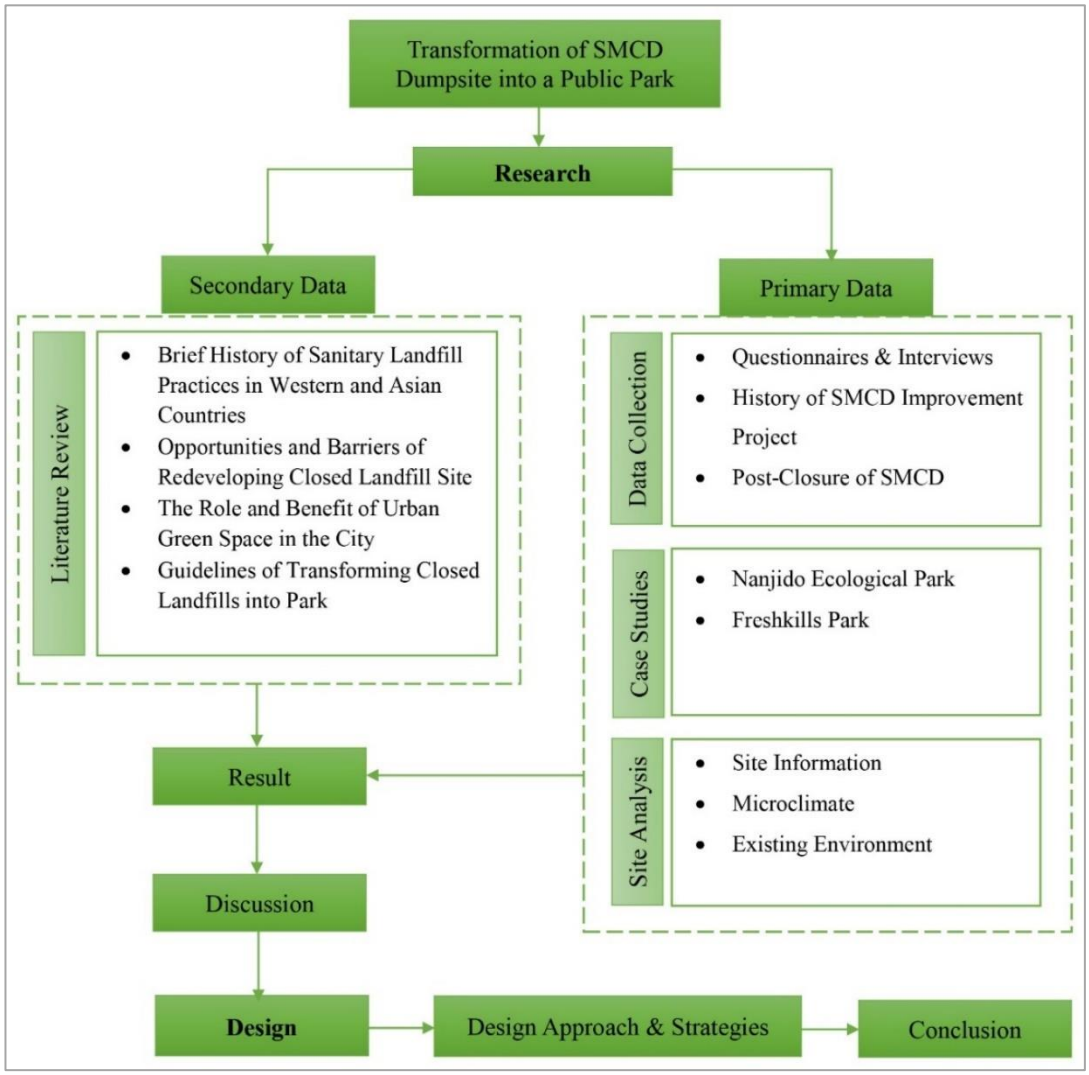


Figure 8. Logic map. Source: Author

4. Data collection

4.1 Questionnaire and interview

Public opinion plays a crucial role in project planning and execution, providing an empirical dimension to the investigation. This survey aims to explore public perceptions of a landfill park project, a concept that does not currently exist in Cambodia. The public's participation in the decision-making process could create a sense of participation and belonging. Lastly, we can find optimal solutions for the target users by identifying public concerns, preferences, and needs.

4.1.1 Survey methods

This survey is conducted using both the online questionnaire method and by interviewing with nearby residents near the SMCD area. The online survey specifically targets residents of Phnom Penh, and participants who do not reside in Phnom Penh city have the option to withdraw from the survey. The questionnaires were provided in both Khmer (Cambodian language) and English, allowing participants to freely choose their preferred language. The survey summary was later translated into English. The online questionnaire (**Table 2**) is divided into three sections: Section (1) personal information, education level, location of residence, and access to the public park. Section (2) explores the use of the public park in Phnom Penh and their level of satisfaction. Section (3) explores their opinions on the proposed project to convert a former dump site into a public park. The survey was distributed through the Facebook and Telegram platforms and participation is voluntary.

Face-to-face interviews were conducted among residents living near the SMCD. The interview questionnaire (**Table 3**) is divided into three sections: Section (1) personal information, level of education, length of residency in the community, and access to public utilities. Section (2) focuses on aspects such as community concerns and dislikes. Section (3) explores the community's perspective on the establishment of a park in their community, including any recommendations or suggestions they may have.

4.1.2 Questionnaires sample

Table 2. Online Questionnaire sample (Credit: Author)

Section 1	
Sex:	☐ Male; ☐ Female
Are you: (Single choice)	☐ Cambodian ☐ Non-native
Age: (Single choice)	☐ Under 18 ☐ 18 - 24 ☐ 25 - 34 ☐ 35 - 44 ☐ 45 – 55 ☐ 55 - 64 ☐ 65 or older
Your education level: (Single choice)	☐ Under high school ☐ High school ☐ Bachelor's degree ☐ Master's degree ☐ Doctoral degree
Where do you reside? (Single choice)	☐ Inner city ☐ City edge ☐ Suburb ☐ Rural
Do you lived in gated community (Borey)? (Single choice)	☐ Yes ☐ No
Are there any parks within a 500-meter radius of your residence? (Single choice)	☐ Yes ☐ No
How often do you visit parks in Phnom Penh city? (Single choice)	☐ Daily ☐ Weekly ☐ Monthly ☐ Rarely ☐ Never
What are the following factors that influence your decision to visit a park? (Multiple choices)	☐ Accessibility (proximity to your location) ☐ Park amenities (e.g., playgrounds, sports facilities) ☐ Natural scenery and environment ☐ Outdoor fitness equipment ☐ Socialization or gathering with friends. ☐ Cleanliness and maintenance ☐ Safety and security ☐ Variety food options ☐ Temporary place to avoid traffic conjunctions. ☐ Availability of parking ☐ Free entrance

	☐ Others……
In your opinion, do you believe Phnom Penh has sufficient public parks or open spaces? (Single choice)	☐ Yes ☐ No ☐ I don't know
In your opinion, are public parks in Phnom Penh city adequately designed to adapt to the environment and climatic conditions of the city? (Single choice)	☐ Yes ☐ No ☐ I don't know
How satisfied are you with the current park facilities in Phnom Penh City, on a scale of 1 to 5? (Single choice)	1. very dissatisfied 2. Dissatisfied 3. Neutral 4. Satisfied 5. very satisfied
How much time do you usually spend at the park? (Single choice)	☐ Less than an hour ☐ 1 – 2 hours ☐ 2-4 hours ☐ More than 4 hours
How much do you typically spend when visiting a park? (Single choice)	☐ Less than $5 ☐ $5 - $10 ☐ $10 - $20 ☐ More than $20
How would you typically travel to a park? (Multiple choices)	☐ Walking ☐ Cycling ☐ Public transportation ☐ Private vehicle ☐ Private transportation services (Book through mobile App)
Section 2	
What is your opinion on converting Stung Mean Chey Dumpsite into a public park? (Single choice)	☐ I support ☐ I don't support ☐ I don't know
Would you visit the park on SMCD if it is built? (Single choice)	☐ I would visit ☐ I am not sure ☐ I would not
If you would visit, what factors would motivate you	☐ Environmental awareness ☐ Recreation and leisure activities ☐ Learning about landfill transformation ☐ Aesthetic appeal (e.g. Landscaping, art installations)

to visit a landfill-to-park transformation project. (Multiple choices)	☐ Inspire others people to visit the once notorious place that has transformed to a beautiful park ☐ Concern about security (crime, thief, etc.)
Do you have any concerns about this project, whether you choose to visit it or not? (Multiple choices)	☐ Concerns about health risks ☐ Concerns about dumpsite instability or structure ☐ Too far to commute ☐ Dislike of the Stung Mean Chey Area ☐ Concern about security (crime, thief, etc.) ☐ Others……
How important is it to you that the transformation of landfills into parks incorporates environmental restoration? (Single choice)	☐ Extremely important ☐ Very important ☐ Somewhat important ☐ Not important
What features or amenities would make you more likely to visit the transformed park from the former dumpsite? (Multiple choices)	☐ Walking/jogging trails ☐ Picnic areas. ☐ Sports facilities (e.g., basketball court, soccer field) ☐ Dog park ☐ Outdoor fitness equipment ☐ Community gardens ☐ Events and performance spaces ☐ Water features (e.g., ponds, fountains) ☐ Food kiosks or restaurants ☐ Others……
Respecting other park users is essential for creating a positive and enjoyable environment. What activities do you believe should be prohibited within the park? (Multiple choices)	☐ Littering ☐ Excessive Noise (Loud music, singing karaoke, other noisy activities) ☐ Alcohol and Substance Abuse ☐ Hunting or Fishing Without Permission ☐ Destructive Activities (Activities that cause ☐ damage to the natural environment) ☐ Camping without proper permits ☐ Open Fires ☐ Commercial Activities (selling goods or services without permit) ☐ Pets off Leash ☐ Other……
If the park project is approved for construction on Stung Mean Chey dumpsite, and fundraising is needed, would you be willing to contribute to this project?	☐ Yes ☐ Perhaps ☐ No
Please share any additional comments or reflections	…… …….

may you have about the proposal to transform Stung Mean Chey dumpsite into a public park.	…… ……

Table 3. Face-to-Face Interview Questionnaire Sample (Credit: Author)

Section 1	
Sex:	☐ Male; ☐ Female
Age: (Single choice)	☐ Under 18 ☐ 18 - 24 ☐ 25 - 34 ☐ 35 - 44 ☐ 45 – 55 ☐ 55 - 64 ☐ 65 or older
Your education level: (Single choice)	☐ Under high school ☐ High school ☐ Bachelor's degree ☐ Master's degree ☐ Doctoral degree
Monthly income (Single choice)	☐ Less than $150 ☐ $150 - $200 ☐ $201 - $250 ☐ $251 - $300 ☐ $301 - $350 ☐ More than $350
Homeownership (Single choice)	☐ Homeowner ☐ Rental house ☐ House support from the NGO ☐ House built on a rental parcel
Length of residency in the community (Single choice)	☐ Less than 1 year ☐ 1-5 years ☐ 6-10 years ☐ More than 10 years
Do you have access to public utilities (electricity, clean water supply, waste disposal, etc…? (Single choice)	☐ Yes ☐ No
If your home is not connected to the public utility system, what alternative method do you use? (Please specified)	…… ……. …… ……

How do you manage your trash? (Please specified)	☐ Collection service ☐ Burn trash ☐ Dump on the nearby vacant lands or on the streets ☐ Other……
Section 2	
On a scale of 1 to 5, please indicate your level of satisfaction with the quality of life in your community. (Single choice)	1. very dissatisfied 2. Dissatisfied 3. Neutral 4. Satisfied 5. very satisfied
How would you rate the quality of the local roads in your community? (Single choice)	☐ Excellent ☐ Good ☐ Fair ☐ Poor
Does your community experience issues with traffic congestion? (Single choice)	☐ Yes ☐ No ☐ I don't know
What aspects of your community do you dislike? (multiple answers)	☐ Noise ☐ Odor ☐ Visual impact ☐ Littering ☐ Flooding ☐ Crime ☐ Infrastructure ☐ Others……
Do you have any health-related concerns linked to residing in close proximity to the closed landfill? If so, kindly provide additional details. If you have, please specify	☐ Yes, I do ☐ No, I don't ☐ I have no opinion …… ……
Section 3	
Are there any recreational facilities available in your community? (if yes please specified)	☐ Yes ☐ No ☐ I am not sure ……
Where do you like to visit during your weekend or your spare time? (Please specified)	…… …… ……
How significant do you consider the establishment of public parks in your community?	☐ Extremely important ☐ Important ☐ Somewhat important ☐ Not important

(Single choice)	
What is your opinion regarding the possible conversion of the Stung Meanchey dumpsite into a public park? (Single choice)	☐ I strongly support ☐ I remain neutral ☐ I do not support ☐ I am uncertain
What improvements would you like to see in your community? (voluntary answer)	…… …… ……

4.2. History of SMCD improvement project

SMCD was once located on the outskirts of Phnom Penh City. As the population increased, urbanization expanded in the surrounding area. SMCD started operating in 1965, spread over an area of 6.8 hectares and is known as the first largest disposal site in Cambodia. It operated as an open dump without engineering intervention and environmental protection measures. The dumpsite received a diverse range of waste from households, restaurants, shops, markets, schools, street cleaning, hotels, and offices. Specifically, kitchen waste was the largest component, with 63.3% of the total waste composition (Kokusai Kogyo, 2005).

In 2000, the Cambodian government (GOC) anticipated that the dump site would reach its capacity in less than two years, mainly due to the increasing volume of municipal solid waste (MSW) and the encroachment of urbanization to within less than 100 meters from the dumpsite. Therefore, they asked the Japanese government for assistance in both the research and the improvement of the environmental conditions of the SMCD. In response to the request, the Japan International Cooperation Agency (JICA) selected Kokusai Kogyo Co., Ltd. as the consultant to conduct this study.

One of those studies included several pilot projects that focused on the improvement of SMCD, improving the waste collection system, promoting the urban waste compost market, and creating a solid waste data management system.

4.2.1 The Pilot Project

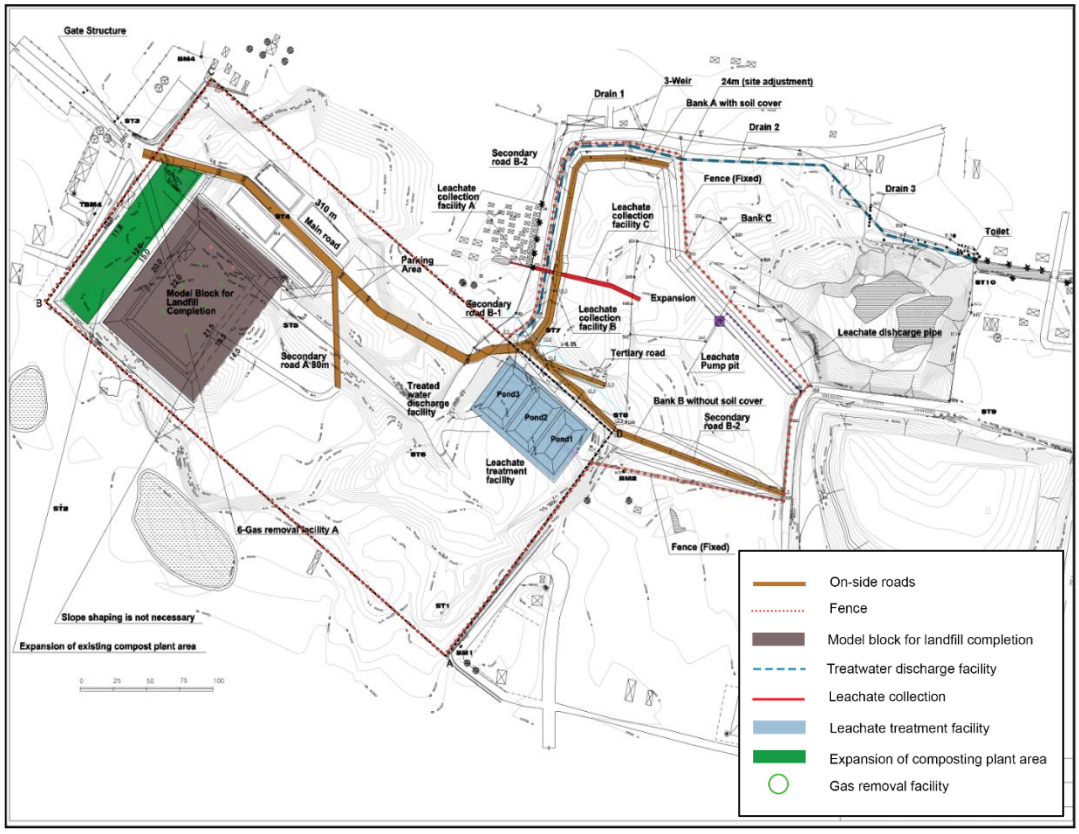


Figure 9. Masterplan drawing of pilot project. Source: (Kokusai Kogyo, 2005)

The purpose of the pilot project was to evaluate the transition from an open dump to a sanitary landfill. The project started on 13 October 2003 and finished at the end of February 2004. The scope of work included: 1) on-side road, 2) working face, 3) fence and gate, 4) model block for landfill completion, 5) enclosing bank, 6) leachate collection, 7) leachate treatment facility, and 8) expansion of existing compost plant area (**Figure 9** & **10**) (Kokusai Kogyo, 2005).

Figure 10. SMCD before and after pilot project. Source: (Kokusai Kogyo, 2005)

4.2.2 Life of SMDC waste pickers

During the operation SMCD, roughly 2,000 people, and about 600 of them were children, lived and worked at the site. They made temporary shelters from waste materials, collected recyclable items, and even scavenged for leftover food within the dump (**Figure 11**) SMCD posted significant hazards, with numerous accidents resulting in death and injury among waste pickers. According to the Global Atlas of Environmental Justice, the soil near a landfill contains cancer-causing dioxin and heavy metals among children that worked at the site. Other health issues reported include salmonella infection, skin and respiratory irritations, diarrhea, headaches, chest pain, and stomach pain (Ej Atlas, 2022). Nearby residents and waste pickers called SMCD as “Hell on Earth”. Despite the hazards, those socially vulnerable groups struggled to survive there due to extreme poverty.

The dumpsite attracted international media attention, particularly for 'poorism' or ‘emigration tourism’, tarnishing the city’s reputation. Following the closure of SMCD, the new Choeung Ek landfill opened about 7 km away. To address the issue of waste pickers and poor tour, the city council banned access to the new landfill site. Many of the waste pickers continue to live around SMCD, some defying the restriction and continue to earn their living in the new landfill.

After the story of waste pickers in SMCD was exposed internationally, they received support from outsiders, especially the Cambodian Children’s Fund (CCF), a non-profit organization established by Scott Neeson. CCF, in cooperation with World Housing, supports waste picker children by offering educational opportunities and housing to their families. Three hundred 4x4 meter houses on stilts were built on rented parcels near the SMCD (**Figure 12**), and certain agreements were established before providing the houses. These agreements included commitments to send children to school, refrain from any forms of abuse (physical, alcohol, drugs, etc.), and prohibit children from engaging in paid labor. These efforts were made to secure the safety environment for children.

Figure 11. Waste pickers made their livelihood through SMCD. Source: maciejdakowicz.com

Figure 12. The household offering to waste picker's family support by CCF & World Housing – right picture is the house's interior. Source: cambodianchildrensfund.org

4.2.3 Closure and Post Closure of SMCD

In April 1999, a Sub-decree was issued regarding Solid Waste Management (SWM), establishing the legal framework for regulating SWM to protect both health and the environment (Royal Government of Cambodia, 2009). According to the research team of (Kokusai Kogyo, 2005) this Sub-decree lacks sufficient information and specific guidelines for SWM, and fails to provide a list of hazardous waste or methods for its identification. Consequently, in 2002, there were instances where factories improperly disposed of hazardous waste in unauthorized areas, stored waste below acceptable standards, and even discharged waste into the environment, including the municipal solid waste collection and disposal system (SMCD), leading to air and water pollution, and posing significant risks to informal waste recyclers (waste pickers) in terms of safety and health. The absence of responsibility in managing site operations, coupled with the lack of a landfill plan or operational program, has had negative effects on the surrounding environment. This includes air

pollution resulting from waste incineration and leachate seepage into underground and surface water bodies.

Several years after the completion of the pilot project, in 2009, the PPCH officially announced the closure of the landfill due to trash accumulating to an average height of over 5 meters, which made it difficult for waste collection trucks to operate and access the site. The site was too small to accommodate the MSW of more than a million people. The trash also spread in surrounding areas and private parcels, further worsening the situation. The new disposal site, situated 10km from the SMCD, began operations immediately after the closure of the old one. However, this new site is reaching its capacity, and the government is currently conducting a study on a designated location of new disposal site.

No official information was available on the final cap procedure and post-closure care for SMCD. However, according to the Guidelines on Solid Waste Management in Cambodia (Ministry of Environment of Cambodia et al., 2006), the final closure process for a landfill should be completed within six months after it ceases operation. This process involves several steps: compacting the final layer of waste, covering it with soil at least 1.5 meters thick to promote plant growth and prevent rainwater percolation, monitoring and controlling leachate and landfill gas twice per year until they no longer pose environmental risks, and maintaining fencing functionality. The last step is re-culturing, which involves planting grass or plants on the soil cover to prevent stormwater infiltration. However, the guideline does not specify the expected standards for landfill caps, including a gas ventilation layer, a protective impermeable layer, and a drainage layer.

Through observation of the site, it is evident that SMCD lacks proper closure management. The dump site is inadequately fenced, allowing public access, and contains tons of old and new rubbish scattered around. The waste mounds are covered with invasive plants and some areas were eroded due to waste decomposition. Some parts of the waste pile have been removed and filled with new soil layers (**Figure 13**). A private company has reportedly generated carbon credits through diversion in the SMDC, as stated by "Ngan San Sreypov," an authority in the Ministry of Environment (MoE).

There is currently no information available regarding the future land use of this area, although the Phnom Penh masterplan (**Figure 14**) designates it as a park and recreational area. However, there is no guarantee that certain areas designated in the

master plan will adhere to it. A prominent example is the ongoing trade and filling of wetlands in Phnom Penh for new developments.

According to a Cambodian newspaper, Koh Sontepheap, who interviewed Keo Pich Mony, the mayor of the Mean Chey District, revealed uncertainty about the future use of this area under the administration of the Phnom Penh Capital Hall (PPCH). He mentioned possibilities such as a school, a shopping mall or hospital but expressed uncertainty. He also mentioned private investment in the site, though specific development plans are unknown. "Ngan," employed at the Ministry of Education (MoE), also mentioned that PPCH must submit a request and proposal plan to the MoE for improvement efforts. She acknowledged that this process was complex but stated that she had not been informed of any plans in this area.

Figure 13. Photos captured on SMCD 2023. Source: Author

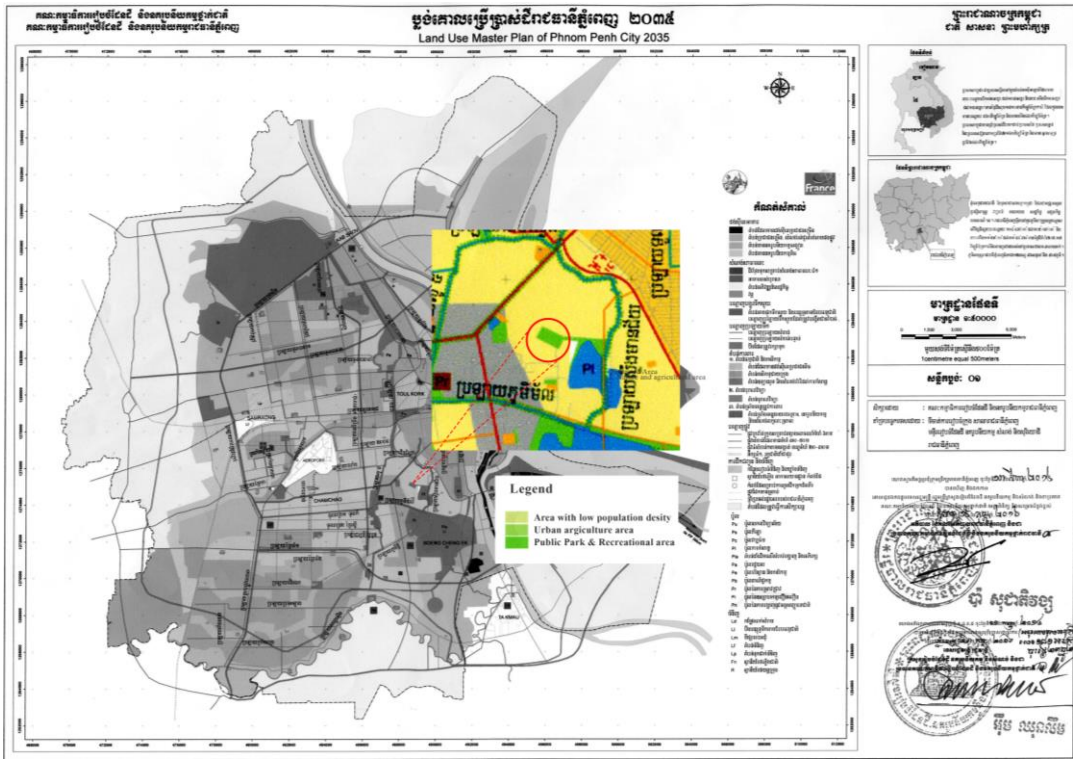


Figure 14. Land Use Master Plan of Phnom Penh city 2035. Source: Phnom Penh Capital Hall

5. Case studies

5.1 Nanjido ecological park, Seoul, South Korea

Nanjido, once a small, beautiful island abundant with orchids and gromwells, underwent a transformation due to rapid urbanization and economic growth. Unfortunately, the government, struggling to find a large-scale landfill to manage Seoul's waste, selected Nanjido as the official dump site in 1978. The island was chosen due to its strategic location, which provides convenient access from downtown Seoul.

Nanjido operated as an open dump, without modern techniques and hygiene practices to treat leachate and gas. Over the course of 15 years, the site operated without any layer of soil covering. In 1993, when the garbage heap reached a height of 100 meters, the waste disposal stopped receiving municipal waste (**Figure 15**). It is important to note that Najido used to provide a livelihood for socially vulnerable people who resided around the dump.

In 1997, Seoul made the decision to construct a World Cup stadium near Nanjido to host the FIFA World Cup in 2002. Improvement in the environment became a necessity for the government before the World Cup began. The landfill in the park project aimed to establish a “symbiotic relationship" between nature and human culture, fostering harmonious co-existence. Its purpose is also to demonstrate to the world that contaminated land, symbolizing the adverse impact of urbanization and industrialization, can be revitalized into ecological space (Seoul Metropolitan Government, 2017).

Figure 15. Najido dumpsite before redevelopment. Source: Seoul Metropolitan Government

5.1.1 Landfill stabilization process

To accelerate the project to host the World Cup 2002, eight areas of development were carried out at the same time, including the stabilization of landfills, the design of Pyeonghwa Park, Haneul Park, the greening of surrounding areas, Heemang Forest, Noeul Park Nanjicheon Park, and Najni Hangang River Park. Landfill stabilization and ecological park construction were completed in 2002 after a total duration of 4 years and 10 months. However, the waste buried beneath Nanjido was biodegraded and the stabilization process was expected to continue until 2020. The focus of the initial phase of the project was on land stabilization, followed by shaping the land into a park. This stabilization process involved four major developments: leachate treatment, landfill gas collection and processing, slope stabilization, and topsoil cover for grass fields. These efforts were made to mitigate the risk of landfill to the surrounding environment. The stabilization work is described in the (**Table 4**), with the master plan (**Figure 16**), section view (**Figure 17**), and detail (**Figure 18**).

The total cost of the Nanjido Ecological Park project is 232.2 billion KRW, with 140.5 billion KRW allocated for stabilization and 82.7 billion KRW for park development. All expenses were covered by the general fund of Seoul.

Table 4. List of construction activities for Nanjido Stabilization. Source: (Seoul Metropolitan Government, 2017)

Category	Construction list
Leachate treatment	• Installation of impervious walls around the landfill area • The construction interception and treatment facilities for slope leakage and leachate • After leachate underwent treatment in double treatment facilities, it was sent for combined treatment before being sent to underground water treatment facilities.
Gas Treatment	• The gas from waste decomposition was captured using a gas collection system. • This system comprised 106 extraction wells, HDPE pipelines, a blower, incineration facilities, and reuse facilities.
Slope stability	• To stabilize the slope, 9m of horizontal drain plates were

	installed to ensure safety against slope collapse and reduce rainwater infiltration.
Topsoil Cover	• The resting slope is built around 4%, for smooth rain drainage. • To properly cover the landfill, 1.4 meters composed of 30 meters of the top layer, 30 cm of vegetation layer, 30 cm of HDPE (high-density polyethylene) drainage layer,1.5mm of blocking layer HDPE sheet and 50cm of bearing layer were added

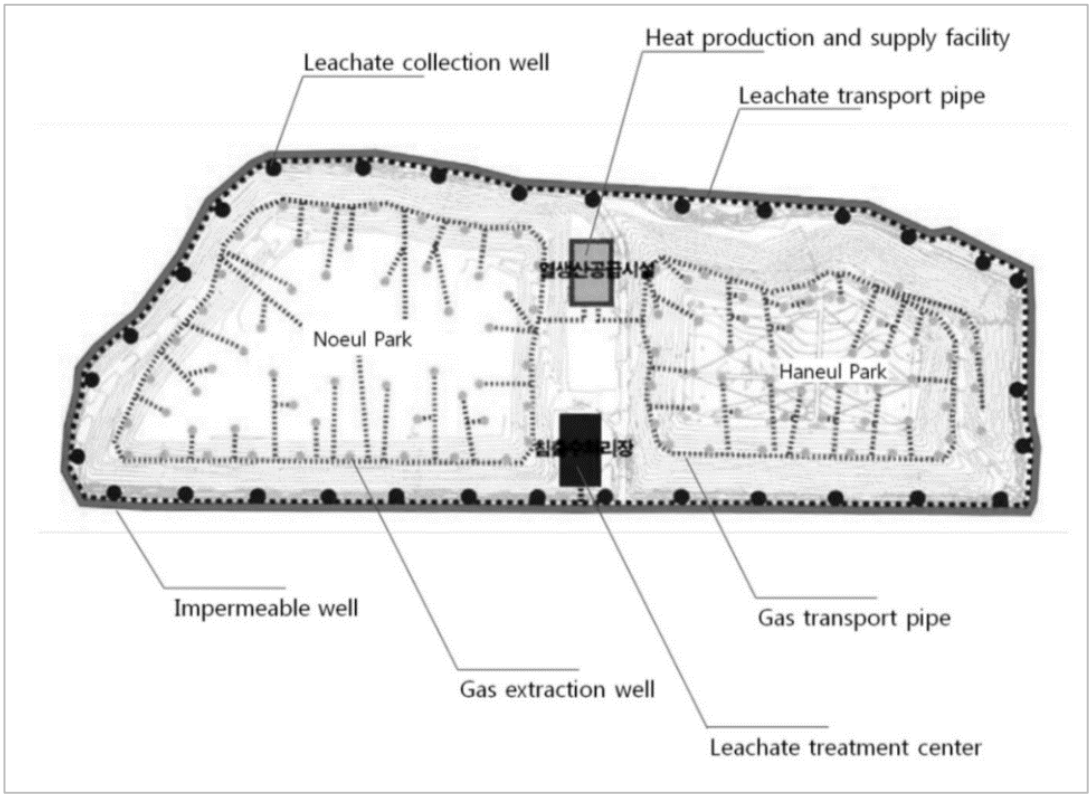


Figure 16. Master Plan of stabilization work. Source: (Kee-young et al., 2014)

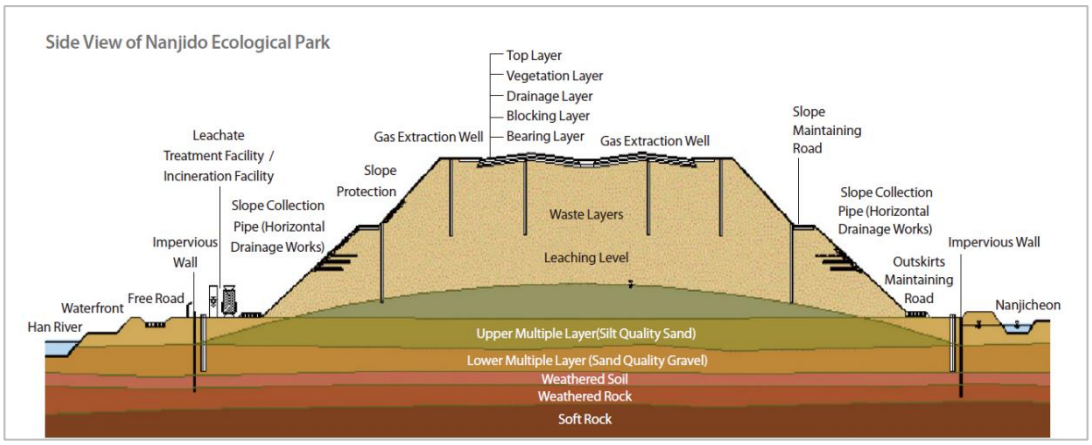


Figure 17. Section view of Nanjido' stabilization work. Source: (Seoul Metropolitan Government, 2017)

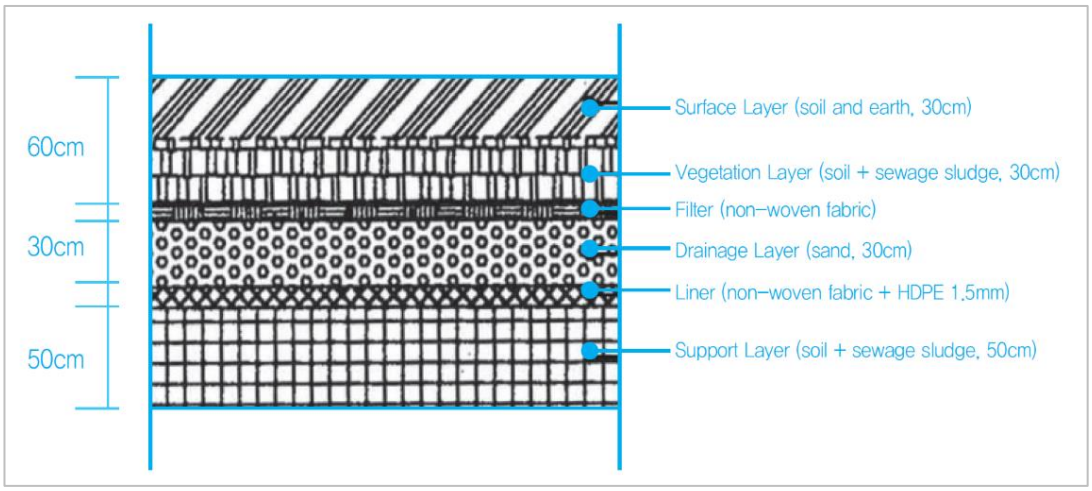


Figure 18. Detail standard of Nanjido topsoil layer. Source: Seoul Metropolitan Government, 2017)

5.1.2 Design of Nanjido ecological park

The Nanjido Ecological Park consists of five member parks: Pyeonghwa Park, Nanjicheon Park Haneul Park (Landfill No. 1) Noeul Park (Landfill No. 2) and Naji Hangang Park, covering approximately 318.182 m^2. To ensure the sustainability of the project, the Mapo Resources Recollection Facility was built between Noeul Park and Haneul Park. These newly built facilities enhance Nanjido's resource recycling capabilities by providing heating for districts, leachate treatment plants, and landfill gas collection facilities. Additionally, the facility functions as an environmental education space, providing citizen site visit programs, and showcasing a symbolic building for the envisioned ecological city (**Figure 19**).

Figure 19. Bird's eye view of Nanjido Ecological Park. Source: Google map

5.1.3 Environmental benefits

Seoul has systematically analyzed and monitored the ecological recovery and the status of Nanjido. The ecosystem and the surrounding environment have made significant improvements. Within 3 years, lush greenery, including plants and trees, covered the slope of the garbage pile and plant species increased. The number of flora and fauna has grown from 438 species in 2000 to 1,092 in 2013. Shows a positive sign indicating a reduction in pollution, a reduction in pollution and the revitalization of Nanjido. Nanjido Ecological Park has been honored with one of the most prestigious awards from the United Nations Human Settlement Program (UN-Habitat) for its landfill recovery projects, recognizing its remarkable contribution to the development and improvement of human settlement and urban life quality.

5.1.4 Economic and social benefits

The methane gas extracted from the landfill can potentially to supply energy for heating in the World Cup Stadium, office buildings, and the 16,335 households in the vicinity. Between 2002 and 2014, the amount of gas generated from the landfill amounted to 43,851,787 m3, equivalent to an annual value of 73,089,000 KRW (approximately 1,295,072.53 Czech crowns). However, the amount of landfill gas decreases as the landfill is stabilized.

As the ecosystem and environmental conditions around the site's value improve, the cost of land increases. For example, in 1996, the land cost was 900,000 KRW per m2, rising to around 1,500,000 KRW in 1999.

Nanjido attracts 10 million visitors annually, offering opportunities for people to participate in various activities, such as festivals, performances, camping, and golf. Visitors can explore and learn from this successful landfill transformation project. In addition, many international communities are interested in learning from Seoul's experiences and insight (**Figure 20**).

A. Haneul Park

B. View from Noeul Park to Han River

C. A bunny found on Haneul Park

Figure 20. Nanjido after the implementation of the ecological park project. Source: A) mur.com.mo B) Seoul Metropolitan Government C) discoveringkorea.com

5.1.5 Challenges and solutions

The Nanjido Ecological Park project faced difficulties in relocating urban poor residents near the landfill site after its closure in 1993. The closure included closing the waste-collecting workplace of Nanjido residents. Although residents insisted on staying there would obstruct development and pose safety risks. Seoul addressed the issue by granting apartment purchase rights to 1,000 households. About 400 households resisted relocation until Nanjido was chosen as the World Cup site.

The collapse of the landfill bank caused a potential disaster; therefore, Seoul provided jobs, housing rights, and relocation support to those who agreed to move. Another issue was a conflicting idea between the Seoul City Government (SCG) and The Korea Sports Promotion Foundation (KSPD) about the purpose of Noeul Park. KSPF was selected as an investor to develop a golf course, and SCG wanted to create a park. In the end, Neoul Park was transformed into a family-friendly park instead of a golf course

5.2 Freshkills Park, New York, USA

Freshkills, located on Staten Island, was transformed into a landfill in 1948 as a temporary waste disposal solution for New York, serving as a temporary solution for waste disposal in response to the increased consumption in the post-World War II United States. The initial short-term solution was extended to 50 years, eventually becoming a primary landfill in New York City. The landfill received an average of approximately 29,000 tons of waste daily and accumulated approximately 150 million tons of solid waste.

In March 2001, the site was closed and in September of the same year, the City of New York announced the International Design Competition for Freshkill Park. The draft masterplan proposed a 30-year regeneration period, recognizing the site's evolving nature. The plan highlighted opportunities and future uses and outlined a phased implementation considering physical and regulatory constraints. The masterplan included visual representations of the site's changing appearance and a process for continuing public participation as the plan is implemented and ensuring the park response to nature and community needs over time.

5.2.1 Landfill engineering (Final Cover/ or Landfill Cap)

Over time, waste materials decompose, and gas and leachate will be removed from the landfill. This natural process reduces the height of the landfill mount by 10-15%. Most of this settlement occurs within the first 5-10 years after the landfill stops receiving waste, with a gradual settlement continuing for at least another 20 years.

The Freshkills landfill is highly engineered and incorporates a sophisticated system for the collection and treatment of by-products such as gas and leachate. This system protects both the public and the environment.

The goal of landfill cap is to provide hydraulic performance, slope stability, and long-term durability. The cover minimizes water infiltration, prevents erosion, promotes effective drainage, isolates waste layer from the environment, and captures and prevents the release of air pollutants. The final cover for solid waste is constructed in phases, consisting of series of layers, each with distinct functions, described in (**Table 5**) and section detailed in (**Figure 21**).

Table 5. Series of layers for the final cover of Freshkill. Source: (New York City, n.d.)

Construction List	Function in Details
Soil Barrier Layer	The final soil barrier must be completed before placing the final cover. • Intermediate cover material, also known as the cover foundation or sub-base, is graded, and compacted at suitable angles. Adjustment of slopes is necessary to meet New York State DEC's required grades (4% to 33%) for slope stability and to promote proper drainage.
Gas Ventilation Layer	• The gas vent layer is a thick geotextile designed to collect and absorb gas in the soil. This geotextile consists of two synthetic fabrics bonded to a hard plastic netting. Placed over the soil barrier layer, it absorbs gases moving upward and directs them to the landfill gas collection system through the empty space.
Impermeable Plastic Liner	The most important component of the final layer • The impermeable plastic liner or hydraulic barrier is placed on the sub-base material to prevent water from entering waste. Blocks the flow of water directly and promotes water storage or drainage in the upper layers. This layer prevents the upward movement of gas into the atmosphere. The material is composed of low-permeability or plastic materials.
Drainage Layer	Drainage layer is needed in some part of the final cover • This layer reduces water pressure on the barrier layer, increases friction, minimizing the risk of sliding, while also draining the protective layer above. This helps increase water storage capacity and lowers the chance of over-

		saturating the cover soils above.
Barrier Protection Layer	•	This layer protects the hydraulic barrier from extreme weather, preventing cracking or heaving in the underlying layers. It is made up of a 24-inch-thick soil layer. Additionally, this layer stores excess water for plants or drains it off as needed.
Planting Soil Layer	•	The topsoil layer must be at least 6 inches deep and fertile. Sandy loam has been chosen as the preferred soil type for erosion prevention and as a suitable medium for plant growth. The goal of this vegetation layer is to control erosion and protect the integrity of the Final Cover. This is achieved through a network of plant roots, which contribute to stability.

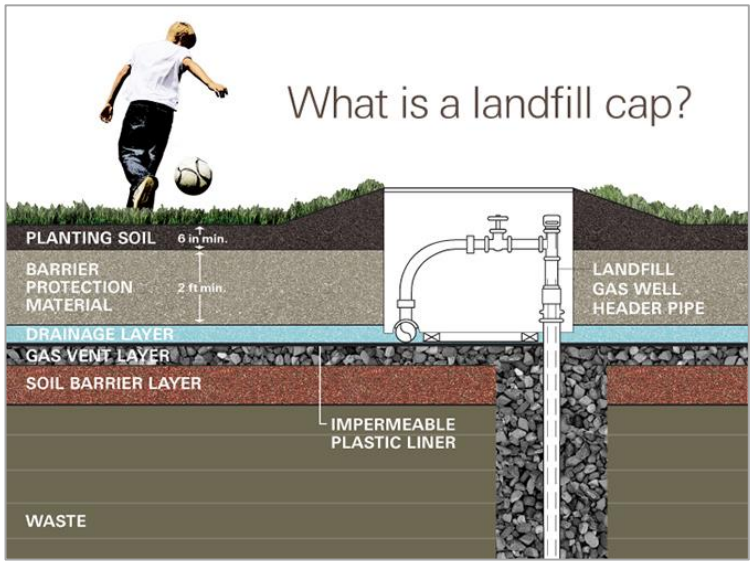


Figure 21. Final cover in detail section. Source: nycgovparks.org

5.2.2 Environmental and public health and monitoring

The SWM regulation is mandated to implement environmental protection measures to prevent pollution from landfills, both present and future. Due to the nature of the landfill, the decomposition could take at least 30 years to complete. The continuous maintenance of the integrity and system is necessary, particularly the final cover, the landfill gas and leachate system, and monitoring wells. These systems must be well-preserved for inspection, maintenance, and repair during these extended periods.

Water Monitoring

Freshkills Park has 238 strategically placed groundwater monitoring wells, including shallow, intermediate, and deep bedrock wells. Monitoring is carried out once every three months in each well. Surface water in Freshkills, Main, and Richmond Creeks is monitored annually at 14 sampling stations, and four stations are also assessed for benthic ecology in intertidal and subtidal zones.

Soil Monitoring

Monitoring soil in accordance with the guidelines provided by federal and state hazardous material management programs is crucial to assess whether the soil poses a threat to human health or the environment. This assessment is carried out on a case-by-case basis, considering the likely pathways and duration of exposure to adverse impacts. The "screening level" risk assessment model presents a level below which there is little concern based on assumptions about potential exposure.

Air Quality Monitoring

Landfill emissions consist of nonmethane organic compounds or methane. The Fresh Kills gas containment and collection system comprises a landfill cap, gas collection trenches, and header pipes that transport the gas to one or more collection points on site. This system collects gas for reuse by the National Grid or for controlled flaring. The flare stations serve as a safety backup in case the recovery system fails. Eventually, when gas generation from landfill ceases and the extraction system becomes economically unviable, any remaining methane will flare off.

5.2.3 Design of Freshkills draft master plan

Freshkills Park covers 2,200 acres, is nearly three times the size of Central Park and stands as the largest park to be developed in New York City in over a century. The project aims to restore the ecological system and cultivate sustainable landscape. It aims to establish a distinctive setting for a variety of unique activities and programs in the city, paying tribute to the events of September 11 and the recovery efforts in Freshkills in a dignified manner. Furthermore, the project also involves the construction of ecologically sensitive park roads to improve local and regional access,

thus reducing traffic congestion (New York City, n.d.). Freshkills Park is composed of five main areas (**Figure 22**) namely the Confluence, North Park, South Park, East park and the West park.

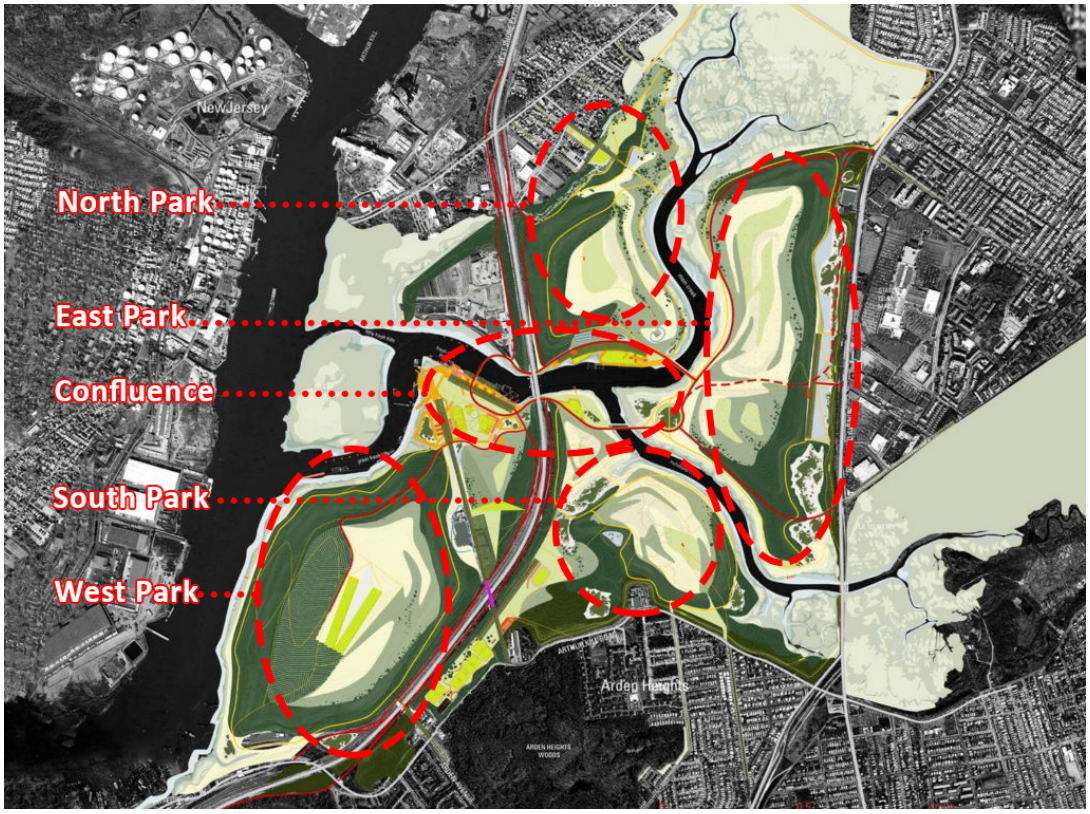


Figure 22. Draft masterplan of Freshkills Park with the five main areas. Source: https://freshkillspark.org/

5.2.4 Early impression of the landscape

'James Corner (a landscape architect and theorist responsible for designing Freshkills Park), said that Freshkills is envisioned as a living, dynamic and evolving landscape that is constantly changing and growing. In its sense, it never reaches a final state; it is always going to change". Due to the nature of landfill evolution over time and the large scale of the site, it is unlikely that Freshkill Park to be constructed once in perfection. Instead, the design process is implemented in this evolving landscape. The inspiration for building the landscape at Freshkills draws from forestry management techniques, where foresters try to construct complex forests of multi-aged trees at various stages of growth (**Figure 23**) a landscape, gradually adding complexity over time and forming a diverse mosaic of woodlands, meadows, and wetlands. This

design process will observe what will happen in the first few years and subsequent years.

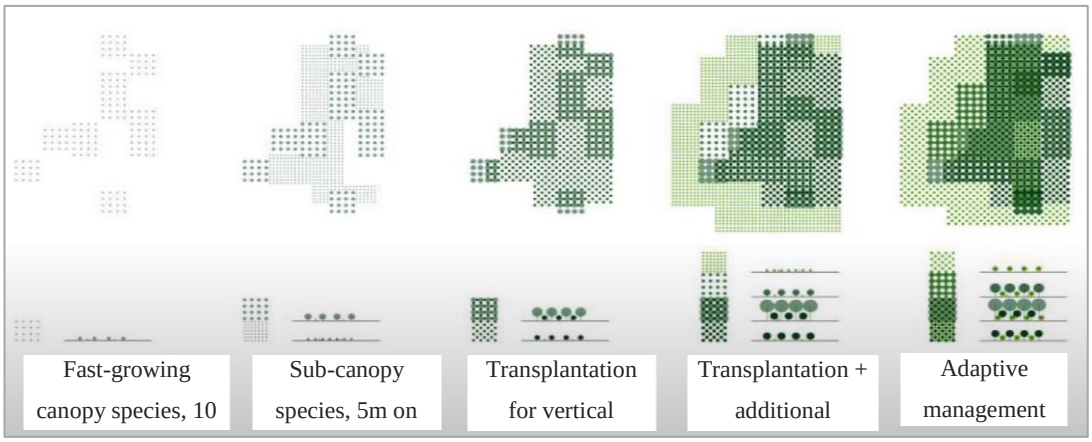


Figure 23. Diagram of forest development in different stages, Source: Beyond the High Line: Transforming Fresh Kills, Staten Island

Instead of importing new soil from different locations that would cost many expenses, crops with high organic content were planted in the landscape. Every six months, these crops were mowed or plowed into the soil. This method has shown that, after five years, a highly organic topsoil layer of six to nine inches can be generated. Imprinting machines rolled on landfill slopes to create small pivots that help establish new plantings. These pivots, positioned on the slope, prevent stormwater runoff and provide locations for seedlings to take root (**Figure 24**).

Collaboration with local centers of native plants is crucial for establishing a mix of native meadow mix using seeds native to the area. This initiative contributes to the creation of a more biodiverse, ecologically robust and sustainable meadow on the newly formed soil landscape. Additionally, efforts have been made to restore existing landscapes, such as tidal flats and tidal creeks in Freshkills, enhancing biodiversity and bringing more life into the park.

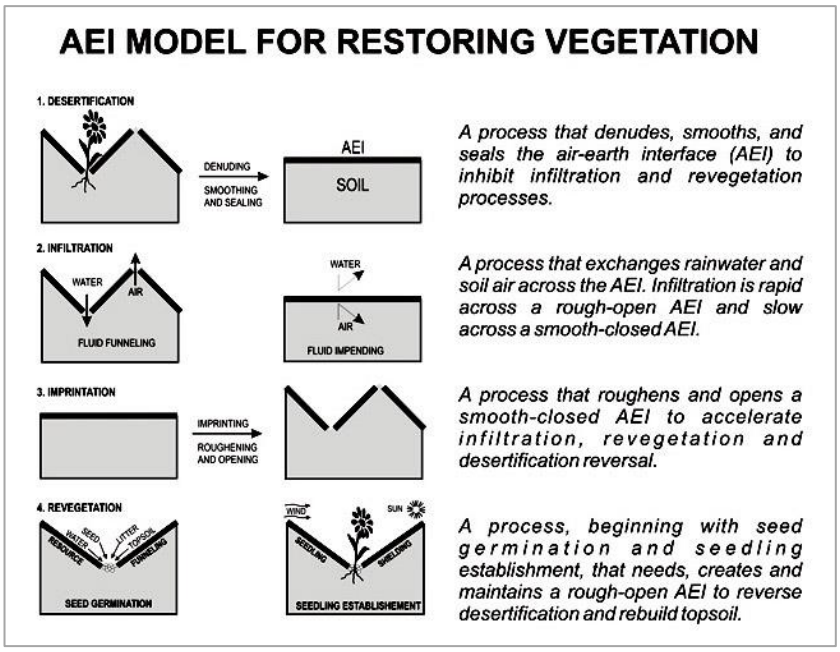


Figure 24. Soil Imprinting Method: The Air-Earth Interface Model for reversing global land desertification through water infiltration control at the soil surface. Source: imprinting.org

5.2.5 Challenges

- An enormous number of government agencies, jurisdictions, and stakeholders, along with various community groups, each with different agendas and interests related to the park, presented a significant challenge in achieving clarity and being able to move quickly.
- Large-scale site with a highly complex political environment that requires a significant amount of time.
- One of the main challenges involved technical issues, as the soil that covers the landfill is shallow and clay based, making it inhospitable for landscape growth. The grass seeded by the engineer is robust and effective in stabilizing slopes, but not suitable for promoting biodiversity or supporting public functions. As time passes, the mounds degrade, unevenly deflating as methane gas and leachate cease.

6. Site analysis

6.1 Site Location and Context

6.1.1 Location

The SMCD is located in the Stung Meanchey district, near the border with the Boeng Tumpun district in Phnom Penh city (**Figure 25**). The topography of the entire city is predominantly flat and low, ranging from 4m to 14m above sea level, with most urban areas located at 7-10m above sea level.

Figure 25. Location of SMCD. Source: Author based on Google Maps

6.1.2 Road networks

The road network is comprised of Active boulevard, secondary active roads, underground roads, local roads, local active roads, and the Bailey bridge (**Figure 26**).

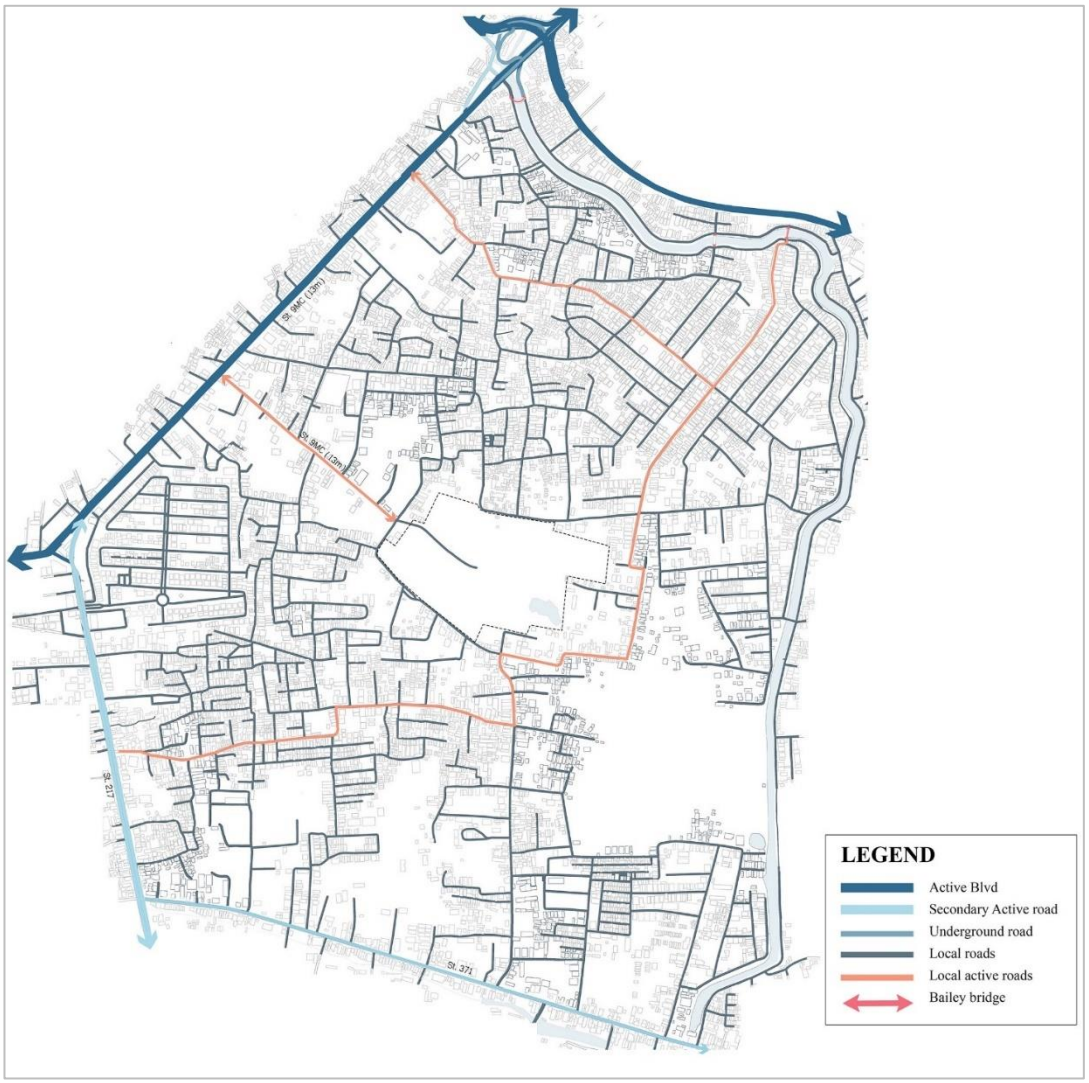


Figure 26. Road networks. Source: Author

6.1.3 Proximity to the Urban Core & Public Transportation Line

This map shows the proximity from SMCD to the urban core is within less than 2km (**Figure 27**)

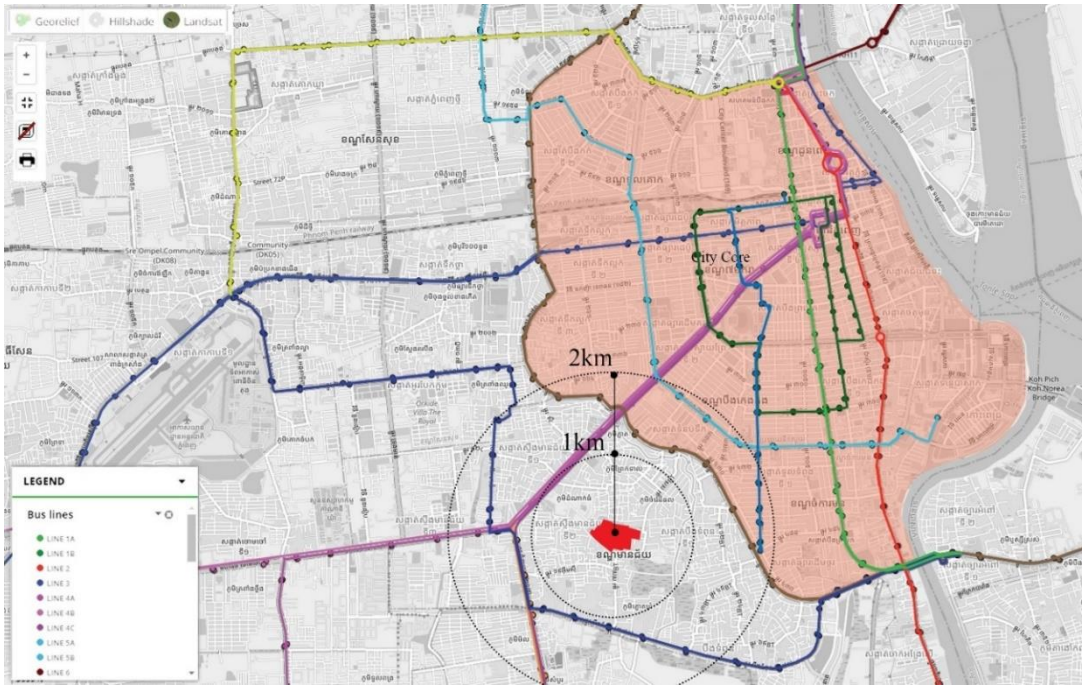


Figure 27. Bus transportation line and distance to the urban core. Source: author & Open Development Cambodia

6.1.4 Neighboring contexts

In the vicinity of the Stung Mean Chey dumpsite, a blend of urban functions, primarily residential. Shops and services are mostly located along the bustling boulevard, although there are also a few of factories and warehouses within the area. (**Figure 28**)

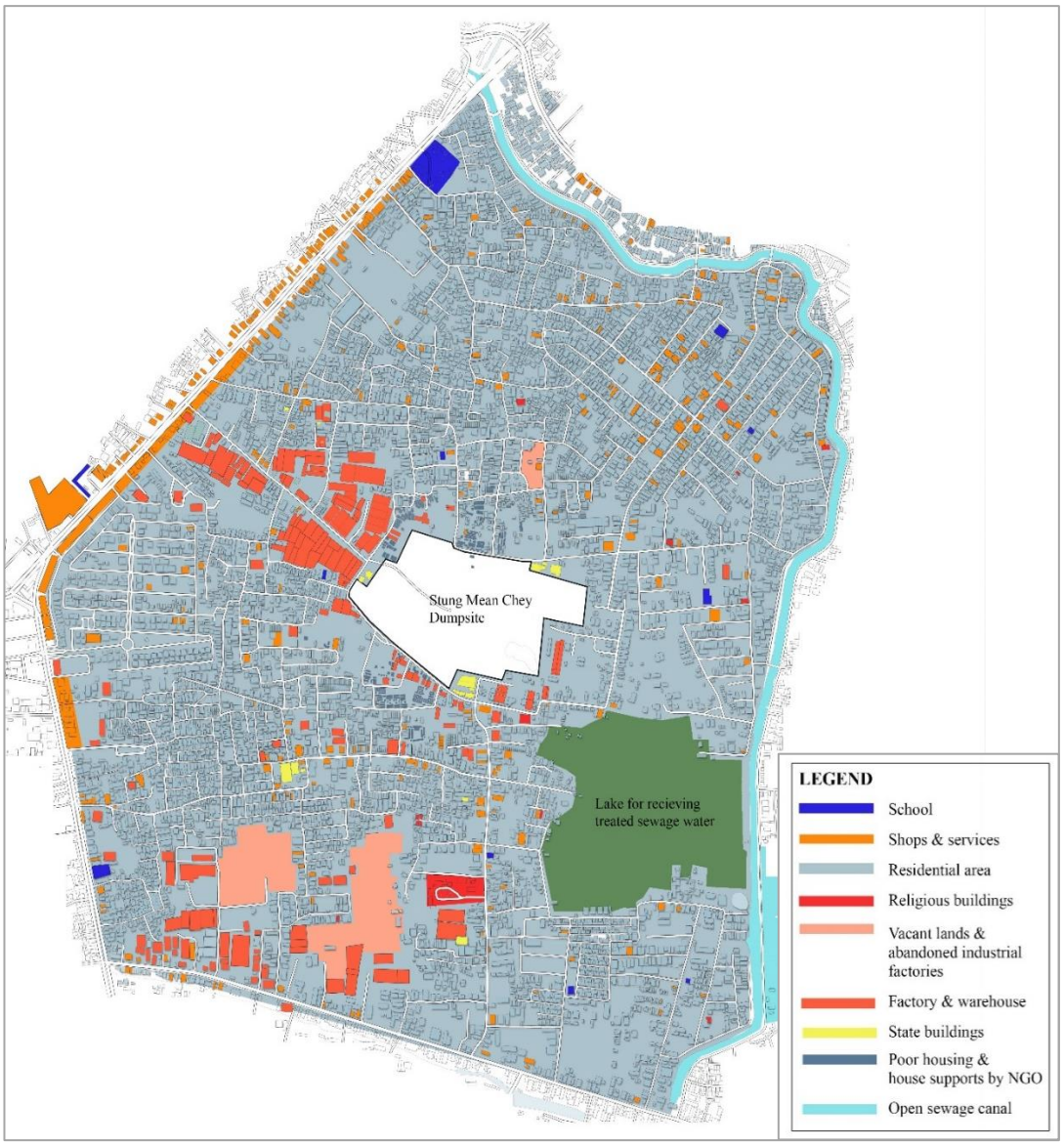
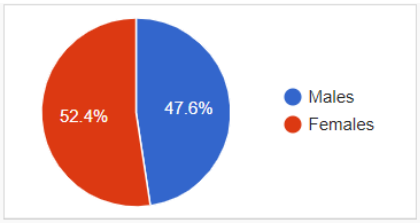


Figure 28. Neighboring contexts. Source: Author

6.2 Demographic information

- The Stung Meanchey district covers 10.46 km^2.
- Population density – 11,997/ km^2 (Census 2019)
- Annual population change – 3.2% (Census 2019)
- Population – 125,481 (**Figure 29**)



Gender (C 2019)	
Males	118,242
Females	130,222

Figure 29. Population structure information. Source: citypopulation.de/en/cambodia/admin/1206__mean_chey/

6.3 Physical Characteristics

6.3.1 Climate

Phnom Penh's weather is warm and tropical throughout the year, with an average annual temperature of 27.8 °C and the annual precipitation of 1432 mm (**Figure 30**).

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature °C (°F)	27 °C (80.6) °F	28.4 °C (83.1) °F	29.6 °C (85.3) °F	29.8 °C (85.6) °F	28.9 °C (84) °F	28.1 °C (82.6) °F	27.8 °C (82) °F	27.6 °C (81.7) °F	27.1 °C (80.8) °F	26.8 °C (80.2) °F	26.7 °C (80) °F	26.4 °C (79.6) °F
Min. Temperature °C (°F)	22.6 °C (72.6) °F	23.5 °C (74.3) °F	25.3 °C (77.5) °F	26 °C (78.8) °F	25.8 °C (78.5) °F	25.4 °C (77.7) °F	25.1 °C (77.2) °F	25 °C (77) °F	24.6 °C (76.3) °F	24.2 °C (75.6) °F	23.7 °C (74.6) °F	22.6 °C (72.8) °F
Max. Temperature °C (°F)	31.7 °C (89.1) °F	33.4 °C (92.2) °F	34.6 °C (94.3) °F	34.7 °C (94.5) °F	33.4 °C (92.1) °F	32.3 °C (90.2) °F	31.9 °C (89.5) °F	31.8 °C (89.2) °F	31.1 °C (88) °F	30.6 °C (87.1) °F	30.5 °C (86.9) °F	30.7 °C (87.2) °F
Precipitation / Rainfall mm (in)	17 (0)	9 (0)	41 (1)	86 (3)	163 (6)	157 (6)	159 (6)	185 (7)	255 (10)	246 (9)	86 (3)	28 (1)
Humidity(%)	60%	57%	60%	66%	75%	77%	77%	78%	82%	83%	76%	66%
Rainy days (d)	2	1	5	11	17	17	18	19	20	18	9	4
avg. Sun hours (hours)	9.3	9.4	9.3	9.5	9.7	9.9	9.8	9.6	9.0	8.4	8.5	9.1

Figure 30. Average temperature, precipitation, humidity, and sun hours. Source: climate-data.org

6.3.2 Geographical and Geological Condition

The city lies on a flat alluvial plain where the Mekong River, Tonle Sap River and Bassac River converge. The soil type beneath the SMCD is composed of an alluvial plain deposit, and its subsoil type consists of silt, sand, clay, gravel, and organic matter.

The urbanized area in Phnom Penh was developed on reclaimed land using river sediment, resulting in soil with low bearing capacities. Consequently, the construction of high-rise buildings requires extensive foundations, and the pavement is susceptible to a reduced lifespan.

6.3.3 Flood Information

The Phnom Penh city is prone to flooding due to its geographical location, climatic conditions, and especially lack of urban planning (**Figure 31**). According to a survey conducted by JICA, 60% of Phnom Penh lies below the elevation of the river (**Figure 32**) (Srey & YAGUCHI, 2023). The city is susceptible to both flash flooding and alluvial flooding. Flash floods occur very frequently, primarily due to inadequate hydraulic systems. However, the recent development continues to encroach on natural reservoirs. Flood protection in the city is heavily dependent on gray infrastructure, with the main sewer system remaining from the French colonial period (Nich, 2019).

The Stung Meanchey district is partially located below the river elevation. The SMCD area is located above the river's elevation. This area is in the category of medium risk for flood susceptibility compared to other locations in the city.

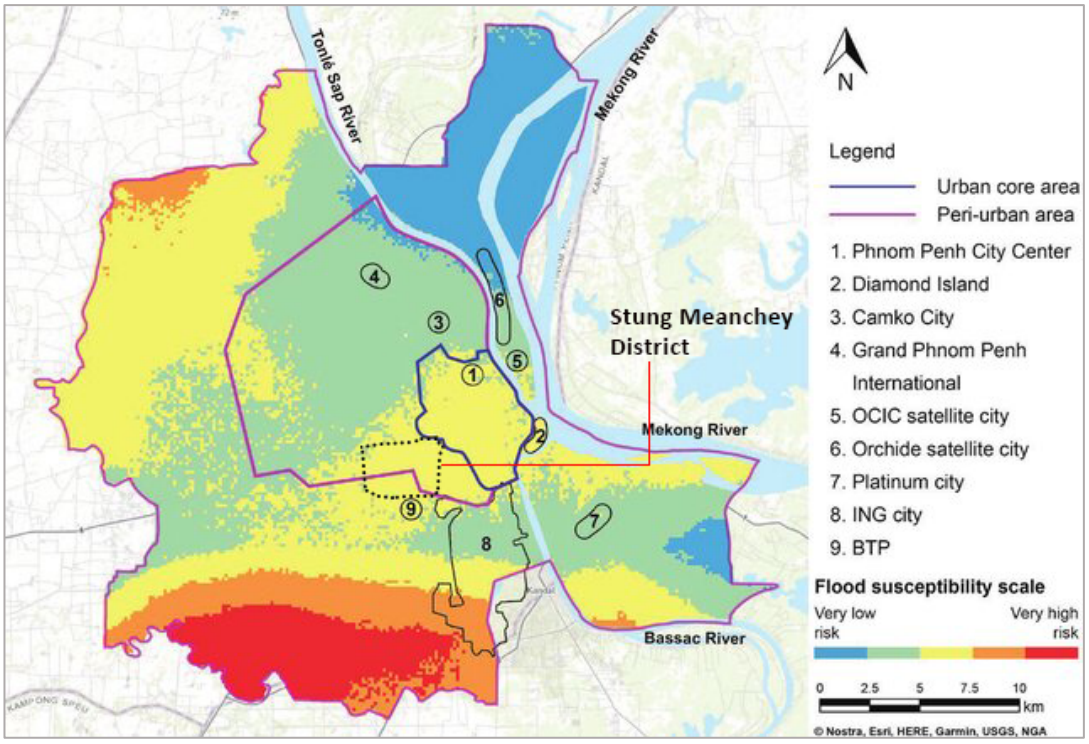


Figure 31. Figure Map of Flood risk in Phnom Penh. Source: (Nich, 2019)

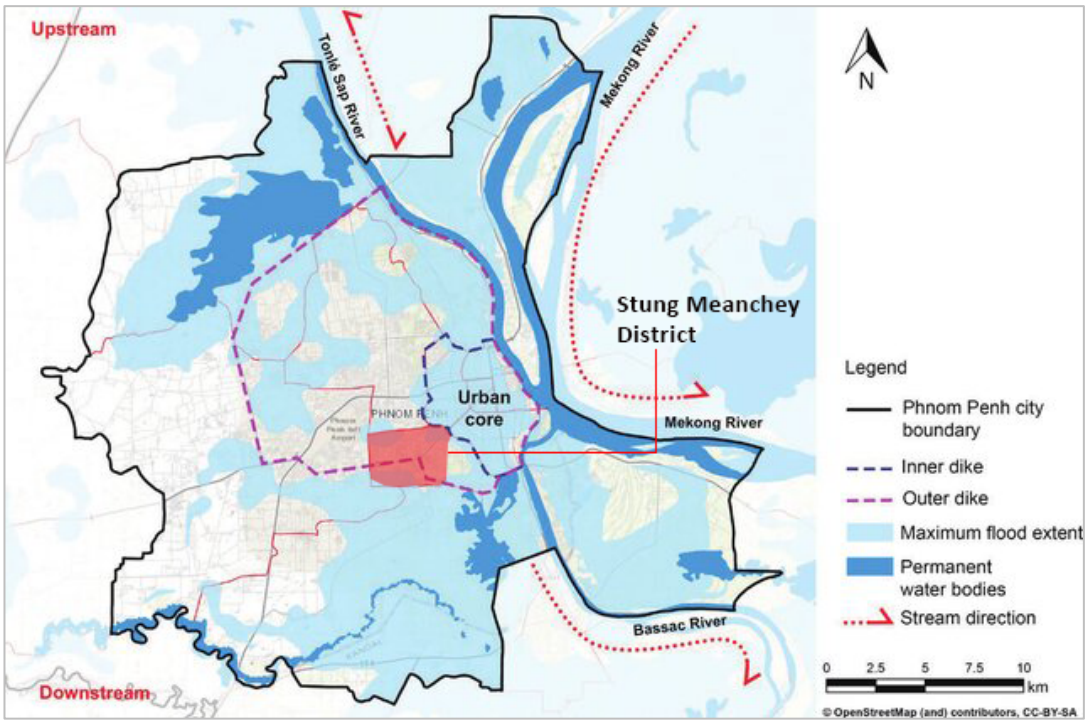


Figure 32. A map illustrating the maximum flood extent in Phnom Penh. Source: (Nich, 2019)

6.4 Land Use

The Land use/land cover of Phnom Penh has undergone rapid changes in the past two decades. The agricultural area and the natural and semi-natural areas were converted into developed areas (**Figure 33**). The city lacks proper planning, neglecting topography, and imperviousness conditions. This oversight contributes to the increase of an urban heat island and puts the city in the risk of urban flooding (Doyle, 2012; Lim & Sasaki, n.d.).

Urbanization also increased around the dumpsite areas due to the scarcity of available space near the city center (**Figure 34**). Residents tend to ignore the potential risks associated with living near the dumpsite, as it is in proximity to the city center.

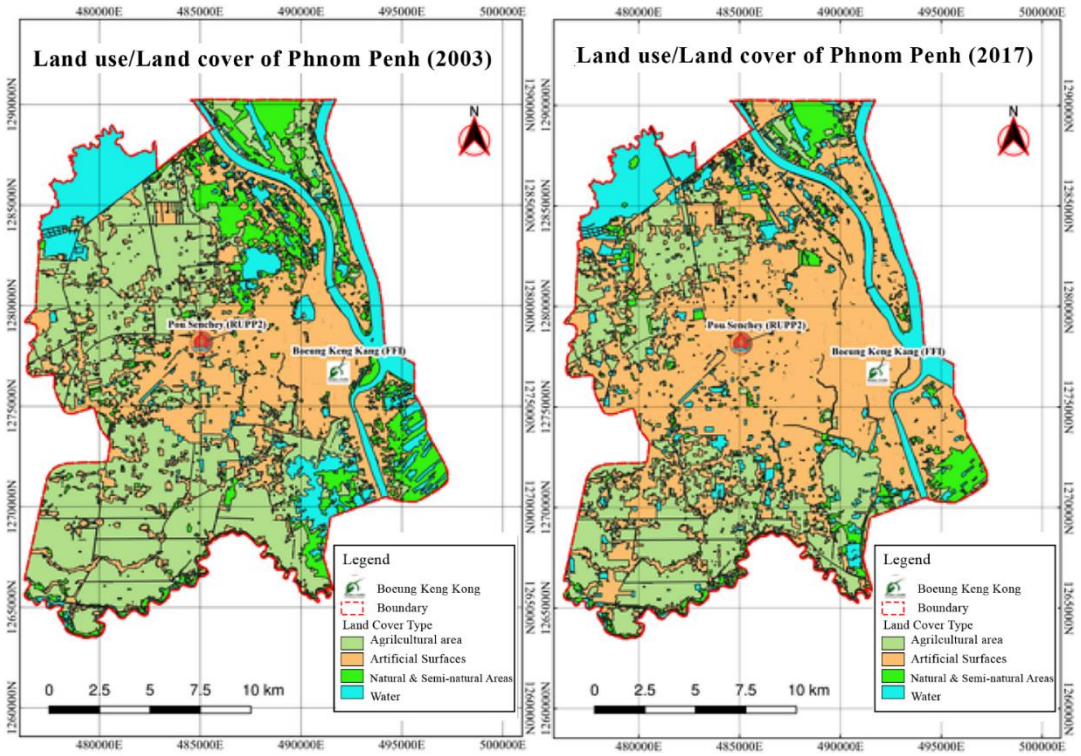


Figure 33. Figure: Change of land use/land cover in Phnom Penh in 2003 and 2017. Source: Urban Climate Recommendations for Urban Planning in Phnom Penh, Cambodia (Se & Katzschner, 2023)

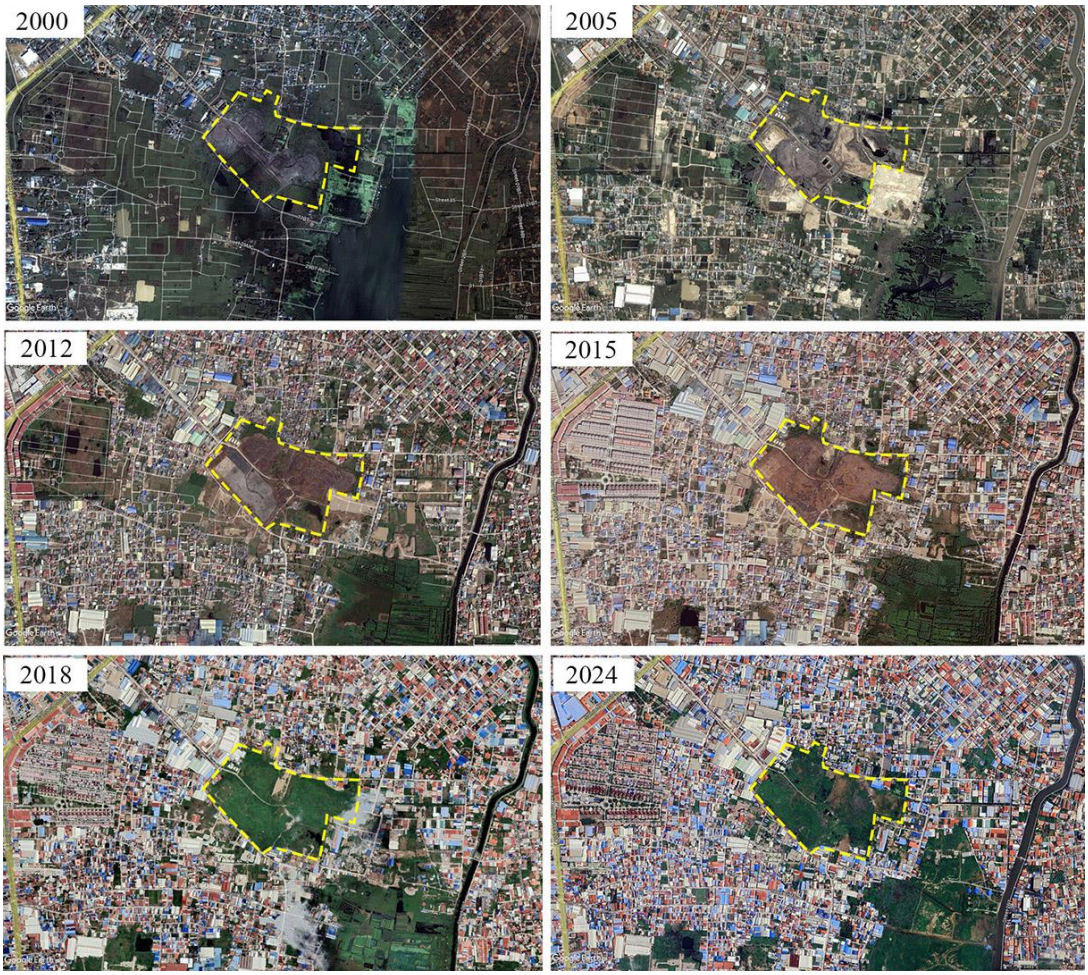


Figure 34. The Satellite map of SMCD area from 2000 to 2024. Source: Google Earth Pro

6.5 Site existing vegetation

6.5.1 Small plants and grasses

Plants and grasses thrive predominantly on the landfill mound, growing naturally without any maintenance. Most of those plants and grasses are invasive species that can tolerate drought, polluted soil, and low nutrient concentrations. The most prevalent plant species found throughout the landfill (**Figure 35**) include the Castor oil plant, Giant milkweed, small white morning glory, *Acalypha indica*, and various other plants and grasses grow partially in the landfill. In addition, some species are toxic and poisonous to humans and livestock.

Figure 35. Plants and grass species found in SMCD. Credit: Author

6.5.2 Big plant and trees

Some trees and banana plants were found in the waste site, which were growing without human intervention. It is believed that the seeds were dispersed by wind, birds, or other animals in the vicinity, or were accidentally brought in during dumpsite operations. Although Jamaican cherry, banana, and wild tamarind fruits are

edible, consuming them is not recommended due to potential soil-containing toxicity (**Figure 36**).

Figure 36. Trees and banana plants grow in SMCD area. Credit: Author

7. Results

7.1 Questionnaire Survey Results

A total of 103 samples were collected from online participants in Phnom Penh City and 40 samples were collected from face-to-face interviews with residents nearby SMCD. 103 of the online respondents were Cambodian and two were non-native.

7.1.1 Online Survey Result

Characteristics of Respondents and the Localization of Their Residents

In this survey the demographic data (**Table 6**) indicates that 55.3% (57) were male and 44.7% (46) were female. Most of the 68% fell within the 24 to 34 (70), followed by 18 to 24 (16.5%) (17). Most of the respondents had a bachelor's degree 50.5% (52) or a master's degree 42.8% (44), with only 4.8% (5) had only a high school education. The majority lived in the inner city, 47.6% (49), with smaller percentages living on the edge of the city, 33% (34), in suburban areas, 17.5% (18) or in rural areas (2 respondents). 65% (67) did not live in gated communities, while 35% (36) did. Unlike those outside gated communities, those in gated communities typically had access to parks within a 500-meter radius.

Table 6. Section 1 Demographic information of the respondents (N = 103). (Credit:Author)

Category		**Frequency**	**Percentage**
Gender	Male	57	55.3
	Female	46	44.7
Age	18 – 24	17	16.5
	24 – 34	70	68
	35 – 44	11	10.7
	45 – 55	1	0.9
	56 – 64	4	3.9
Education level	High school	5	4.8
	Bachelor's degree	52	50.5
	Master's degree	44	42.8
	Doctoral degree	2	1.9
Resident's location	Inner city	49	47.6
	City edge	34	33
	Suburb	18	17.5
	Rural	2	1.9

Residents in gated or non-gated community	Gated community	36	35
	Non-gated community	67	65
Available Park within 500-meter radius of the resident	Yes	34	33
	No	69	67

Information regarding respondents' utilization of parks in Phnom Penh and their satisfaction.

The survey findings (**Table 7**) reveal that most of the respondents in gated communities, the city edge and suburban areas seldom visit public parks in Phnom Penh, while those in the inner city visit more frequently. Approximately 83.5% (86) of the respondents feel the city needs more parks. Additionally, most of the respondents perceive the design of the parks as unsuitable for the city's environment and climate. Satisfaction with current park facilities discloses a nearly uniform balance, with a significant portion expressing dissatisfaction 34% (35) or neutrality 40.8% (42). Most of the respondents, 52.4% (54), spend 1-2 hours in the park, with a smaller percentage, 5.8% (6), spending less than an hour or 2-4 hours. Approximately 74.7% (77) of the respondents spend less than $5 per visit to the park, while 23.3% (24) spend $10 to $20. Most people travel to the park by private vehicle due to distance, with only 7.8% (8) commuting by bicycle and 4.8% (5) by foot.

According to 64.1% (66) of the respondents, the main motivator for visiting Phnom Penh Public Park is its beautiful natural scenery. The second significant factor is free admission, chosen by 44.7% (46) of the respondents. 33% of the respondents also mentioned park amenities, cleanliness, parking availability, proximity to residences, and safety. Approximately 23% are attracted by the variety of food options, parking space, outdoor fitness equipment, and the opportunity to avoid peak traffic congestion (**Figure 37**).

Table 7. Section 2 Characteristics of the respondents concerning their utilization and satisfaction levels of the Phnom Penh public parks. (Credit: Author)

Category		Frequency	Percentage
How often do you visit parks in Phnom Penh city?	Daily	3	3
	Weekly	30	29
	Monthly	18	17.5

	Rarely	51	49.5
	Never	1	1
Do you believe Phnom Penh has sufficient public parks or open spaces?	Yes	11	10.7
	No	86	83.5
	I don’t know	6	5.8
Are public parks in Phnom Penh city adequately designed to adapt to the environment and climatic conditions of the city?	Yes	28	27.2
	No	64	62.1
	I don’t know	11	10.7
How satisfied are you with the current park facilities in Phnom Penh City, on a scale of 1 to 5?	Very dissatisfied	15	14.5
	Dissatisfied	35	34
	Neutral	42	40.8
	Satisfied	7	6.8
	very satisfied	4	3.9
How much time do you usually spend at the park?	Less than an hour	43	41.8
	1-2 hours	54	52.4
	2-4 hours	6	5.8
How much do you typically spend when visiting a park?	Less than $5 (116 Kč)	77	74.7
	$5 - $10 (– 231 Kč)	24	23.3
	$10 - $20 (– 462 Kč)	2	2
How would you typically travel to a park?	Walking	5	4.8
	Cycling	8	7.8
	Public transportation	3	3
	Private vehicle	85	82.5
	Private transportation services (Book through mobile App)	2	1.9

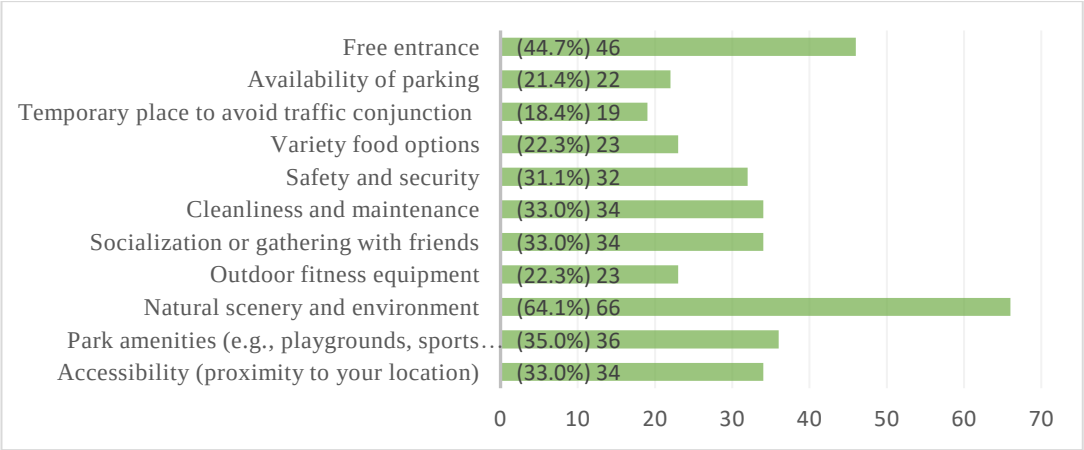


Figure 37. Graph of the factors that influence the decision to visit a park according to the respondents (Credit: Author).

Characteristics of respondents regarding their views on the proposed landfill-park project

Most of the respondents, 92.2% (95), support the proposal to transform SMCD into a public park, while 4.8% (5) do not support it and 2.9% (3) choose to withhold their opinion. Regarding visiting the park once built, 83.5% (86) express their intention to visit, while 15.5% (16) are undecided, possibly due to the distance from their homes, and only one person has opted not to visit at all. Motivating factors to visit include environmental awareness, interest in landfill transformation projects, recreational activities, and showcasing the site's transformation **(Figure 38)**. Concerning potential issues related to the project, 24.3% (25) expressed concerns about security, and another 15.5% (16) were concerned about the nature and stability of the dumpsite. An equal percentage expressed concerns about the distance from their residences, with only a small percentage, 5%, disliking the SMCD area **(Figure 39)**.

When asked about the significance of environmental restoration in the conversion of landfills into parks, 57.3% (59) consider it extremely important, 34% (35) consider it as necessary, and 8.7% (9) find it somewhat necessary. In terms of fundraising, the majority, 63.1% (65), pledge to contribute funds voluntarily, while 34% (35) are uncertain and only 2.9% (3) refuse to donate. Regarding desired parks and amenities, walking and jogging trails garner the most support, with 70.9% (73), followed by picnic areas 69.9% (72) and community gardens 55.3% (57). The preferences for event spaces, water features, or sports facilities are less than 50%, and

less than 40% express a preference for food kiosks, outdoor fitness areas, or dog parks. The respondents also recommend planting large tree species and fruit trees (**Figure 40**).

Respect for fellow park users is emphasized, with nearly 80% opposing abuse, alcohol consumption, excessive noise, and littering. Activities such as selling goods or services without a permit, unauthorized camping, and having off-leash pets are also considered inappropriate. The respondents also suggested that beggars, makeshift huts, and single-use plastics be banned **(Figure 41)**.

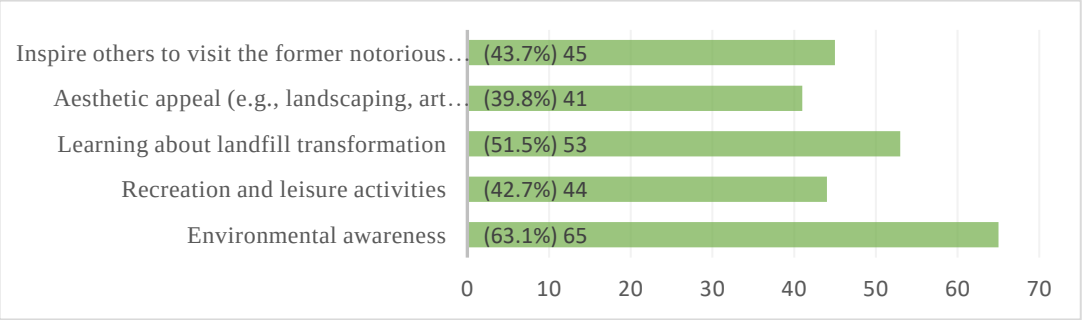


Figure 38. Motivation to visit a landfill-to-park transformation project. (Credit: Author)

Table 8. Section 3 Characteristics of the respondents regarding their opinion on the proposed Landfill-Park project. Credit: Author

Category		Frequency	Percentage
What is your opinion on converting Stung Mean Chey Dumpsite into a public park?	I support	95	92.2
	I don't support	5	4.8
	I don't know	3	2.9
Would you visit the park on SMCD if it is built?	I would visit	86	83.5
	I am not sure	16	15.5
	I would not	1	1

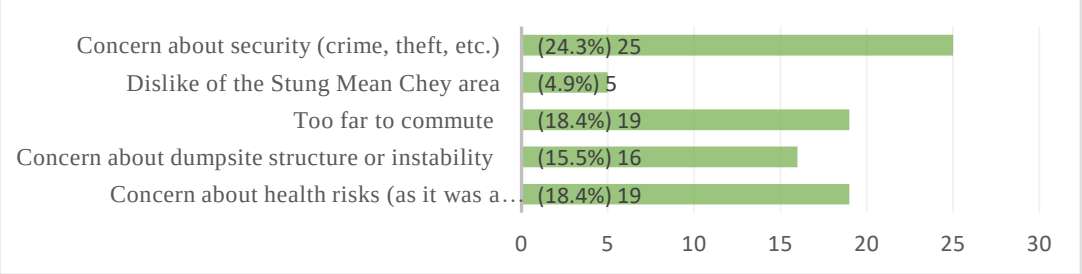


Figure 39. Graph showing the concerns for the transformation project. (Credit: Author)

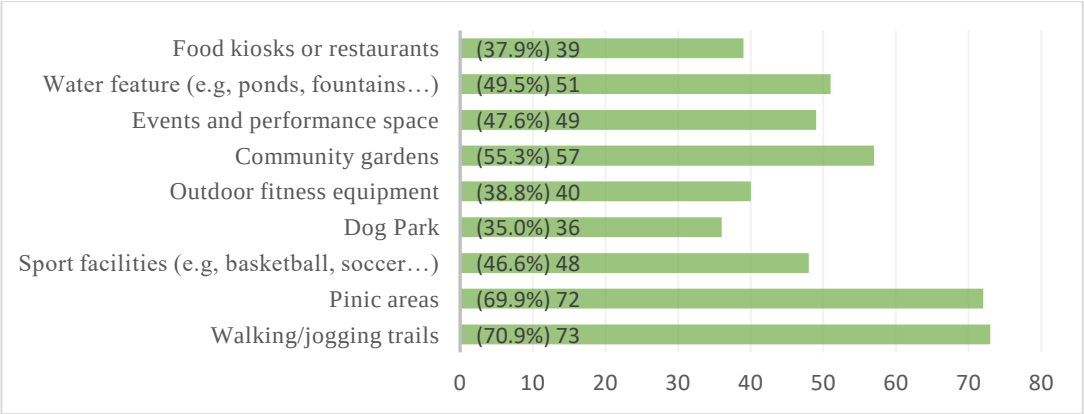


Figure 40. Graph showing what does the park amenities should provide. (Credit: Author)

Table 9. Table showing the interest of respondents for green spaces and willingness to support projects for the development of green spaces. Source: Author

Category		Frequency	Percentage
How important is it to you that the transformation of landfill into parks incorporates environmental restoration?	Extremely important	59	57.3
	Very important	35	34
	Somewhat important	9	8.7
	Not important	N/A	N/A
If the park project is approved for construction on Stung Mean Chey dumpsite, and fundraising is needed, would you be willing to contribute to this project?	Yes	65	63.1
	Maybe	35	34
	No	3	2.9

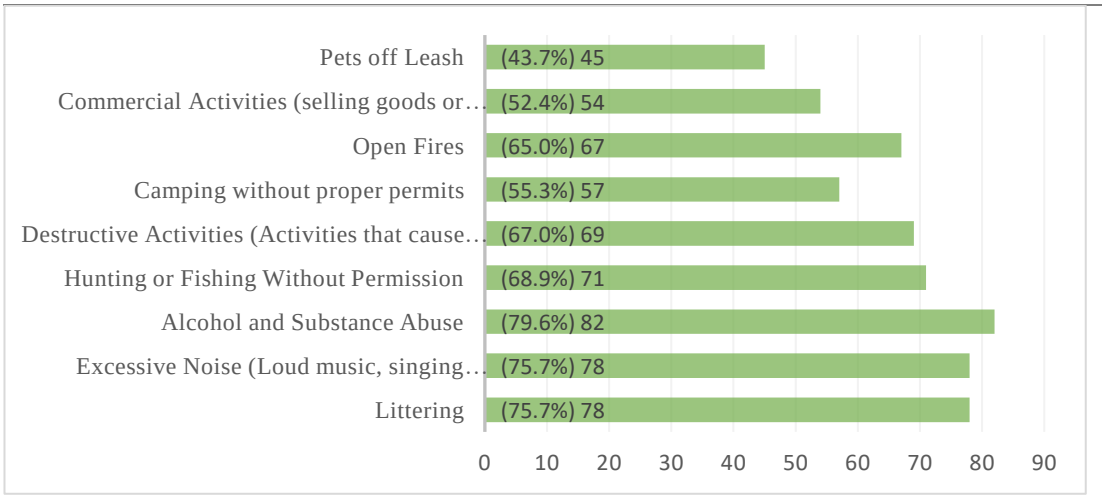


Figure 41. Graph showing what needs to be prohibited in the park to cultivate the park's area. (Credit: Author)

Notable quotes and comments shared by online participants who completed the questionnaire in English included:

- The park itself is a recreation of the garbage dump, and I think including knowledge of how to use plastic and waste management is important. It will be a great message and a lane marker for future awareness of the related issue.
- Some factors should be considered when building, as the landfill still produces methane gas and leachate in these years, esp. digging ponds or water systems and some activities that can cause explosions.
- It is a good idea, I wish to see this idea come to life soon
- Any new park areas are a great addition
- Should think about the safety of radiation and possibility of proposal
- Stung Meanchey dumpsite is not a good idea to create a park. But for me, Phnom Penh has more parks and is an advantage to inspire the government to think more and detail about those areas and to implement more into that.
- Recycling must be encouraged and inspired by people.
- I believe transforming the dumpsite into a park is one of the key to promote urban design and urban restoration of a city. I hope the project will happen as I wish to see more public parks and green spaces in our hectic and polluted city.
- I also hope the dumpsite transformation will create a much healthier community and positively bring a drastic change to the living environment of the people nearby.
- Good idea but maybe difficult to do
- Please consider creating a biodiversity atmosphere inside the park, not only for humans but also for other animals.

Notable quotes and comments shared by on-line participants who completed the questionnaire in Khmer and translated by author:

- Public parks should be built in the Stung Mean Chey area, as currently, there are no existing parks in the vicinity. Parks also contribute to enhancing the beauty of the city.

- I would be genuinely delighted if the project were to happen since it is close to my home. Currently, I have to endure a one-hour commute and deal with frustrating traffic jams whenever I want to visit a park.
- Please find a new location for landfill site and improve the waste management
- Ensure that people no longer perceive it as garbage dump
- I strongly support this project
- I would like to give a feedback to the proposal project of Stung Mean Chey Dumpsite to a public park. While this area served as a dumpsite, it is also the home of former waste pickers. The proposal is commendable for enhancing the city's aesthetics, but I suggested ensuring that any development undertaken does not adversely affect the livelihood of the people in that area.
- Please transform it into a natural park.
- Please plant large trees and included lakes

7.1.2 Face-to-Face Interview Result

Characteristics of respondents and their quality of life

The participants in this survey were 65% (26) women and 35% (14) were male.

Most of respondents were aged between the ages of 30 and 39, which is 30% (12), 27.5% (11) aged 40 to 49, 25% (10) 50 to 59, the youngest respondents were between 18 and 29, accounting for 35% (14), while the oldest was 5% (2).

Regarding the education, the majority had a primary school education level of 40% (16), with almost equal numbers for secondary school and high school at around 20%. The highest level of education attained was a bachelor’s degree, held by two individuals, while 17% (7) were illiterate.

Approximately 62% (25) of the respondents had a monthly income less than $150 (3,465 Kč), with only two bachelor’s degree holders earning around $300 (6930 Kč) monthly. Housing situations varied; 48% (19) lived in houses supported by NGOs (CCF and World Housing), 32% (13) lived in rental accommodations, and 10% each were homeowners or occupied houses built on rental parcels.

Additionally, 48% (19) had lived near SMCD for more than ten years, 35% (13) were newcomers who had lived there for less than five years, and approximately 20% (8) had been residents for less than ten years. Access to public services was common, but some lacked access due to temporary housing. Those without access typically bought energy from other households. Alternative energy sources such as fuelwood, charcoal, and LGP gas were utilized for cooking. Almost every household used septic pump truck services when their septic tanks were full, as the area lacked full access to public sewage pipes or had small sewage pipes in certain streets. Similarly, almost every household used trash collection services, although the collection truck did not come regularly, especially to households located in small alleys. As an alternative, these households would gather their trash near accessible streets, resulting in litter accumulation along the roads.

Table 10. Section 1 – Demographic data of respondents (N=40) (Credit: Author)

Category		**Frequency**	**Percentage**
Gender	Male	14	35
	Female	26	65
Age	18 – 29	5	12.5
	30 – 39	12	30
	40 – 49	11	27.5
	50 – 59	10	25
	More than 60	2	5
Education Level	Illiteracy	7	17
	Primary school	16	40
	Secondary school	7	18
	High school	8	20
	Bachelor’s degree	2	5
Monthly income	Less than $150	25	62
	$150 - $200	9	23
	$201 - $250	4	10
	$251 - $300	2	5
	$301 - $350	N/A	N/A
	More than $350	N/A	N/A
Homeownership	Homeowner	4	10
	Rental house	13	32
	House support from the NGO	19	48
		4	10

	House built on a rental parcel		
Length of residency in the community	Less than 1 year 1-5 years 6-10 years More than 10 years	N/A 13 8 19	N/A 35 20 48
Do you have access to public utilities (electricity, clean water supply, waste disposal, etc…?	Yes No	32 8	80 20
If your home is not connected to the public utility system, what alternative method do you use? (multiple answers)	- Buy electricity and water from other households that is connected to public utilities. - Fuel wood & charcoal. - LGP gas - Septic pumper truck	8 23 32 21	20 57.5 80 52.5
How do you manage your trash? (multiple answers)	- Collection service - Dump on the nearby vacant lands or on the streets. **Additional comments** - *Garbage truck collection does not come regularly, so they place the garbage near the street for collection when the services arrives. (similar response from 19 participants)*	33 9	82.5 22.5

Characteristics of respondents regarding their community-related concerns and dislikes

When assessing the quality of life in their community, 47.5% (19) have a neutral reaction, 7.5 % are very dissatisfied, and dissatisfied responses account for 35%

(14), while satisfaction levels are around 10%. Those who are very dissatisfied reported poverty within their families, low living standards, and slum-like housing conditions. On the other hand, those satisfied mentioned the convenience of location, especially for work and markets, particularly among newcomers or homeowners. Regarding road quality, 22.5% (9) rated the roads as good, 50% (20) rated them as fair, and 27.5% (11) rated them as poor. Almost all respondents reported no traffic congestion.

When discussing aspects they dislike about their community, all respondents pointed out the visual impacts, particularly the negative appearance of the dumpsite. Furthermore, 87.5% expressed dissatisfaction with the smell, 82.5% disliked the way trash littered the streets, and 72.5% complained about flooding during the rainy season. They also mentioned concerns about muddy roads, stagnant water, and the absence of playgrounds for children.

47.5% (19) of the respondents mentioned health concerns related to living near the landfill, while 32.5% expressed no concern and 20% had no opinion. Those concerned about health were primarily former waste pickers who had worked directly at the dumpsite, some of whom had already experienced health problems. The respondents mentioned experiencing headaches due to the smell and expressed worries about potential diseases as they age.

Table 11. Section 2 - Characteristics of respondents about their community-related concerns and dislikes related to the community (N = 40) (Credit: Author)

Category			**Frequency**	**Percentage**
On a scale of 1 to 5, please indicate your level of satisfaction with the quality of life in your community. (Single choice)	6	very dissatisfied	3	7.5
	7	Dissatisfied	14	35
	8	Neutral	19	47.5
	9	Satisfied	4	10
	10	very satisfied	N/A	N/A
How would you rate the quality of the local roads in your community	Excellent		N/A	N/A
	Good		9	22.5
	Fair		20	50
	Poor		11	27.5
Does your community experience issues with traffic congestion?	Yes		N/A	N/A
	No		34	85
	Not sure		6	15

What aspects of your community do you dislike? (multiple answers)	Noise Odor Visual impact Littering Urban flood **Additional comment** - *Stench is stronger in rainy season* - *It used to be a drug trafficking spot near the garbage mound, but police arrested those who were involved, and there have not been recent reports about it.* - *Some roads become muddy during rainy days, making it difficult to drive.* - *The streets are full of rubbish, appearing unpleasant and repulsive.* - *No playground for kids*	4 35 40 33 29	10 87.5 100 82.5 72.5
Do you have any health-related concerns linked to residing in close proximity to the closed landfill? If so, kindly provide additional details	Yes, I do No, I don't I have no opinion **Additional comments** - *When the wind blew over the rubbish pile, it brought odor to my home. I frequently have a headache and my voice becomes hoarse.* - *I occasionally experience stomachache when flies land on our food.* - *In the past, the problem was that garbage burned for a few days, and we all had to*	19 13 8	47.5 32.5 20

	inhale the smoke from burning trash, causing us to feel unwell. - *I personally concern about potential health effects of inhaling the odor from garbage* - *Presently, my health remains stable, but I am concerned that as I age, I may develop some illnesses caused by the pollution from the dumpsite.*	

The recreational hobbies of the respondent and their viewpoint on the transformation of SMCD into a public park.

When asked about the available public recreational facilities in the community, only one person mentioned a small playground built by CCF for local children. 10% stated that they were unsure, while all other respondents reported a lack of recreational facilities in their community. Regarding preferred weekend or leisure activities, 57.5% (23) preferred staying at home, 12.5% enjoyed visiting neighbors within the community due to costs and distance associated with visiting city parks. 22.5% (9) expressed a preference for visiting public parks, primarily younger respondents aged 18 to 29 years. When asked about the importance of establishing a park in their community, 70% deemed it extremely important, while 25% agreed that it was important. Regarding the idea of converting SMCD into a public park, 87.5% (32) strongly supported the project, 12.5% were neutral and 7.5% either had no opinion or had not considered such a project before. Additional concerns raised included poverty alleviation, community aesthetics, government housing support, and the need for better playgrounds.

Table 12. Section 3 - Recreational hobbies of the respondents and their viewpoint on the transformation of SMCD into a public park (N = 40) (Credit: Author)

Category		**Frequency**	**Percentage**
Are there any recreational facilities available in your community?	Yes	1	2.5
	No	35	87.5
	I don't know	4	10

(if yes please specified)	**Additional comment** - Cambodian Children's Fund playground		
Where do you like to visit during your weekend or your spare time? (Multiple answer) Please provide additional details	- Staying at home - Visiting my neighbors in the same community - Visiting a park in front of the Royal palace (public space along the riverfront) - Visiting some parks in the city center - Window shopping - Babysit my grandchildren at my daughter's home	23 5 9 7 4 2	57.5 12.5 22.5 17.5 10 5
How significant do you consider the establishment of public parks in your community? (Single choice)	Extremely important Important Somewhat important Not important	28 10 2 N/A	70 25 5 N/A
What is your opinion regarding the possible conversion of the Stung Meanchey dumpsite into a public park?	I strongly support I remain neutral I do not support I am uncertain	32 5 N/A 3	87.5 12.5 N/A 7.5
What improvements would you like to see in your community? (Volunteer responses)	- I seek the authority to address the issue of flooded roads during the rainy season. - It would be great to provide a spacious playground for children. - I wish to have a spacious and comfortable house for my big family since my current home is too small and uncomfortable. - Alleviate poverty in the community. - Regular garbage		

	collection services would be greatly appreciated. - Improve the aesthetic of the communities by ensuring regular trash cleanup. - Having a recreational facility and public space would be a great addition. (the similar response was summed up into a single phrase)	

8. Discussion

8.1 Phnom Penh's public parks provision versus user experience and satisfaction level

Parks and green spaces are metaphorically called "the lungs of cities," a slogan that has persisted for more than 250 years (Xing & Brimblecombe, 2020). This analogy is relevant in the urban setting, rife with pollution, as urban green space allows residents to breathe fresh air despite pollution. However, achieving adequate parks and green spaces remains a challenge in most developing cities worldwide due to rapid urbanization.

In the context of Phnom Penh, public parks and green spaces often prioritize aesthetic appeal over quantity, quality, and environmental sustainability. Parks are mainly located in historically significant areas or along main avenues within the city core, with a small provision in suburban or peripheral regions, unless private parks within gated communities or private development projects are limited accessible. Compared to the park's total area within the park has seen a marginal increase, from 0.65 km^2 in 2016 to 0.67 km^2 in 2018, a mere 3.07% rise. However, when assessing parks and urban green space per capita, Phnom Penh lags behind when compared to neighboring cities such as Ho Chi Minh ($2m^2$) and Bangkok ($7m^2$), with a mere 0.343 m^2 per person, significantly lower even compared to the busiest city such as Tokyo ($5.5m^2$).

The online survey revealed that 83.8% of the participants recognized the insufficient number of parks and public spaces in Phnom Penh and 49.5% reported rarely visiting the park due to their remote locations or the time-consuming commute to city parks. deteriorated by traffic congestion. When visiting the park, 82.5% of visitors use private vehicles, while only a small minority walk or cycle. This indicates that the parks in Phnom Penh city are not easily accessible within walking distance. Therefore, the usage pattern seems to create social stratification, favoring those living in the urban core or gated communities with parks. This exclusionary trend contradicts the UN-Habita definition of public spaces as inclusive areas accessible to all, regardless of socio-economic status (UN-Habitat, 2018).

Not only are there insufficient parks, but their design also fails to adapt to the city's environment and climate, as 62.1% of respondents indicated. The Phnom Penh typically consists of paved areas, resulting in low permeability and lack of greenery, trees, and the no protection from rain and sun. Consequently, these parks mainly attract visitors in the evening when temperatures are cooler and match the end of work or school hours. The main reason that draws most respondents to visit city parks in the city is their environmental characteristics and beautiful scenery, especially the free entrance, rather than other factors commonly provided by park designs. The interesting result regarding park users' satisfaction with park facilities is that the percentages of those who are very unhappy (14.5%), dissatisfied (34%), and neutral (40.8%) are relatively close to each other. This shows awareness and understanding of what parks should look like and what facilities they should provide. A study on public perception conducted by(Yen et al., 2016) highlighted that the perception of parks can vary greatly depending on factors such as age, race, education, and cultural and social background. The survey shows that most people with higher education levels expressed dissatisfaction or dissatisfaction with the current park facilities. The author assumed that the participants who chose neutrality might have yet to encounter well-designed parks or had no understanding of park features.

The survey revealed that public opinion is important in planning and the design. It is essential that governmental bodies, local authorities, and stakeholders make an effort to educate communities and engage the public. This ensures that the park designs are in line with the needs and preferences. Integrating public discussion into the planning process helps planners envision and create an environment that evokes positive user experiences, promoting well-being and enjoyment among park visitors.

8.2 Discussion of Public's Perception on the Proposed Transformation SMCD into a Public Park

The survey results indicate a remarkably positive response to the transformation of SMCD into a public park. A significant majority of the participants in online surveys (92.2%) and face-to-face interviews (87.5%) strongly support this proposal. This overwhelming support underscores the community's recognition of the

importance of restoring degraded urban areas. Interestingly, 57.3% of the respondents rated the landfill-park project as extremely important for environmental restoration, while 34% considered it very important. This further emphasizes the community's commitment to sustaining the urban environment. In addition, 83.5% of the respondents wanted to visit the landfill park once it was built. Among these, 63.1% want to enhance their environmental awareness, while 51.5% want to learn about the landfill transformation process. This finding demonstrates the possibility of developing this landfill park to function not only as a leisure area but also as an educational hub for environmental sustainability. The response from others conveyed their interest in visiting the park for recreational and leisure activities, a common thought shared by most park users. 43.7% of the respondents wanted to visit the park to inspire others and witness its transformation from a once notorious site into a valuable community asset. This sentiment is reflected in the survey responses, and many participants want to encourage others to visit the park. Despite the enthusiasm of park users, respondents also expressed concerns about the project. 24% expressed concern about the area's previous reputation as a slum with high crime rates and drug trafficking. The health risks related to existing pollution and concerns about commute distance were also mentioned as potential drawbacks. Only a minority (15.5%) expressed concern about the instability of the dump site.

When envisioning an inventory of park amenities desired by visitors, a significant share, ranging from 69.9% to 70.9%, preferred walking and jogging trails along with picnic areas. This highlights the importance that participants place on having spaces for relaxation, lush with grass and trees. Some suggested the inclusion of large trees and expansive grassy areas. Additionally, 55.3% supported the idea of a community garden, while 49.5% would like to include water features. Similar levels of support were observed for facilities catering to sports, event spaces, and performance areas. However, amenities such as food kiosks or restaurants, outdoor fitness equipment, and dog parks garnered less enthusiasm, each receiving votes from less than 40% of the participants.

When shaping the park's rules and regulations, it is crucial to consider the community's preferences regarding user behavior. Prohibiting alcoholism, substance abuse, excessive noise, littering, and destructive activities received more than 75% support from respondents. Other behaviors with significant support for banning, each

receiving more than 65% of the vote, including hunting or fishing without permission. Destructive activities, such as damaging trees or plants and open fires, also vote against ban. Around 50% or more of the votes favor prohibiting camping without permission, engaging in commercial activities such as selling goods or products.

63.1% of the respondents expressed a willingness to contribute to the project financially, emphasizing the importance of creating more parks in Phnom Penh. Beyond financial support, the participants highlighted the need for proper urban planning and design to mitigate pollution and promote biodiversity. Criticism and suggestions for improvement, including improving waste management and recycling efforts, reflect the community's engagement and commitment to the project's success. However, some criticisms regarding safety, a preference for enhancing the current park rather than selecting the former dumpsite, and concerns about the impact on socially vulnerable individuals nearby highlight the importance of incorporating diverse perspectives and addressing potential obstacles during the park planning process.

Therefore, the results of this survey provide an important message to the author, policymakers, and stakeholders: It is imperative to involve public opinion and address their concerns, interests, and visions to achieve social consensus and environmental sustainability in the implementation of the project.

8.3 Visions of the Community Survey and Prospects for Transformation of SMCD into a Public Park

During the interview, most participants were women because they were at home and their husbands were going to work. Most of the respondents are between the ages of 30-49. There is a diverse range of educational backgrounds; most completed primary school (40%), a few finished high school, and seven people are illiterate, while only two hold bachelor's degrees. Regarding income levels, it tends to be relatively low, with most earning less than $150 per month, except for those with bachelor's degrees, who earn approximately $250 to $300 per month. In addition, many of the respondents live in houses provided by NGOs or rental accommodation. Nearly half of the respondents have resided in the area for more than a decade, dating back to when the dumpsites were operational, and they used to live and work directly

on the dump site. Public services are available throughout the area; only those in temporary housing have no direct access to these services, causing daily difficulties. Additionally, irregular waste collection contributes to litter accumulation, diminishing cleanliness and visual appeal.

Interestingly, participant satisfaction levels are divided, with nearly equal numbers expressing dissatisfaction or neutrality. Those who live in NGO-supported housing express their neutrality, citing improved living conditions compared to their past experiences living near dumpsites. However, due to financial constraints, low incomes are preventing them from having the opportunity to entertain, such as visits to public parks. Thus, most prefer to stay home during the weekend or during leisure time. Dissatisfied participants point out poverty, low living standards, and environmental issues such as flooding and trash accumulation as primary concerns. All participants were aware of the negative impacts of dump sites on their community, including visual and odor: half expressed health concerns, particularly former waste pickers who have experienced health problems.

Regardless of social status, participants recognize the importance of having a public park within the community and support the transformation of the SMDC area into one. However, there are concerns about potential development prioritizing financial gain over community benefits and environmental restoration, as the dumpsite is near the urban core. At the end of the interview, participants urged the government to address urban flooding, improve waste collection services, and clean up the community, establishing parks or recreational facilities to enhance their living conditions, promote physical and mental well-being, and improve the community's aesthetics.

8.4 Limitations

Many challenges arose while conducting this study. Due to time constraints and personal ability, the author was unable to collect a higher number of samples from the local interviews, potentially compromising the data convincing. Additionally, the inability to measure the current waste volume, waste pile height, and soil condition as well as predict the dumpsite settlement. The existing database concerning site closure,

post-closure activities, and future land use in the area is insufficient. These research limitations require collaboration with experts from various fields to create an appropriate site-specific design.

9. Design strategies and approach

9.1 Recommendation for the SMCD Rehabilitation Approach

MCD operated without implementing environmental protection measures. Consequently, the site became contaminated with dioxins and heavy metals (Ej Atlas, 2022), severely impacting the surrounding environment and public health. The closure of SMCD did not follow the international standard procedure for landfill closure and post-closure management, which requires maintenance and monitoring for 30 years.

The suggestion for SMCD is to initially improve the site condition by implementing landfill rehabilitation methods, as outlined in the case studies chapter **(Table 4)**. This method was chosen due to its similarity to the operational manner of an open dump that lacks environmental protection. However, the choice of equipment and technologies depends on the availability of tools and resources, knowledge of the operation, and the adaptation to site-specific characteristics. Furthermore, to protect the environment and public health from dumpsite pollution, SMCD should establish a system for collecting and treating leachate and methane gas to ensure regular maintenance and monitoring procedures.

In addition to the engineering layers, Phytoremediation is recommended on top of the soil layer. Phytoremediation is a plant-based approach to remediate contaminated soil, which helps to reduce heavy metals, explosives, and oil (EPA, 2012; University of Arizona, 2012). This method can either use trees or grassland, which is cost-effective and environmentally friendly (Jones et al., 2006; Kafle et al., 2022)

Another alternative method inspired by the Freshkill landscape design process is creating a nutrition layer for soil. This method is called “Green Manure” and is defined as plowing fresh green plants into the soil; when plants decompose, it creates soil organic matter, providing natural fertilizer (Shah Alam et al., 2022).

In conclusion, applying the phytoremediation technique and incorporating the green manure method can further help restore the contamination and provide cost-effective solutions that suit Cambodia's financial constraints while promoting an environmental sustainability approach.

9.2 Recommendation of Trees and Vegetation

9.2.1 Recommendation of Trees

These trees are resistant to pollution, thrive in poor soil conditions, and purify air quality. They are frequently used as street trees and are native to Southeast Asia.

Figure 42. Pollution resistant trees. Credit: Author

9.2.2 Recommendation of indication plants

These plants, both native and introduced species, are readily found throughout the country. They are resistant to contamination and poor soil conditions and require minimal maintenance.

Figure 43. Indicator plants recommended for SMCD. Credit: Author

9.3 Design proposal

Master plan design (**Appendix 1**)

Litter garbage will be excavated and loaded adjacent to the existing compacted mount. The purpose is to compact and seal the waste and create a new garbage mound. An existing leachate collection pond will remain in place. A new central axis is suggested for the northern and southern parts to facilitate emergency access. Park amenities listed in the (table) are based on survey references, with additional facilities proposed for site maintenance and monitoring.

Table 13. Proposal of function and amenities of SMCD Park. (Credit: Author)

Category	Features
Nature and landscaping	• Trees • Plants and flora • Picnic areas • Birdhouse and bee house • Bioswale
Path	• Walking/jogging trail • Trail stairs • Skywalk
Recreational facilities	• Playground • Embankment Slides & net • Performance area
Sport facility	• Football and basketball fields • Outdoor fitness
Community engagement	• Dog park • Community garden
Hardscape	• Parking lots • Farmer markets and food stand • Restroom s • Staff houses and maintenance buildings • Gas collection and treatment buildings • Leachate treatment building • Garbage storage

Compacted waste section (**Appendix 2**)

This section shows the height and layers of the proposed final cap design.

3D perspective (**Appendix 3**)

Visualization of SMCD Park.

10. Conclusions

This thesis has explored the fact that landfill transformation into parks is complicated but feasible. The landfill-park project is one of the common end uses for urban landfills to address environmental concerns and the scarcity of green spaces in densely populated areas. Numerous literature reviews and case studies demonstrate that the design and implementation of landfill-park projects require collaboration across various fields of expertise, engaging stakeholders, and especially incorporating public opinion. Moreover, due to the evolving nature of landfill sites, they demand effective planning and long-term management strategies.

The landfill-to-park project holds promise for addressing urban environmental challenges in Phnom Penh by mitigating pollution resulting from poor waste management and addressing the shortage of public parks. Creating green spaces becomes increasingly crucial as available land becomes scarce and prioritized for hard-use development.

As this masterplan design is proposed in this study, it is crucial to engage public opinion; the research part incorporates public opinion through interviews and surveys, revealing that most participants strongly support this project. The author also gain insights into the preferences and perceptions of Phnom Penh residents regarding park features. By presenting a list of park amenities, participants could envision their desired features, emphasizing having more greenery and trees.

Beyond environmental benefits, the landfill-to-park project can foster community engagement, raise environmental awareness, and enhance residents' quality of life. It offers an opportunity for nearby residents previously affected by dumpsite impacts to enjoy improved environmental quality and recreational opportunities and potentially create job opportunities. Additionally, it can increase the property values of the surrounding site.

Besides numerous benefits, this project presents many challenges, such as technical capabilities and funding, that need to be addressed through collaboration and innovative solutions. Conflicts between stakeholders may arise, with funding and decision-making. In conclusion, converting SMCD into a public park presents a potential solution for tackling the issues of increasing MSW and the scarcity of urban

parks. This project could serve as a model for policymakers and government bodies to consider creating a program to manage closed landfills or dumpsites to restore the degraded urban environment, promote environmental awareness, and provide more green space for the city.

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