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Comparative Analysis between Landfill Food Waste in Liberia and China

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ABSTRACT

Management of solid refuse is a crucial issue confronting nation worldwide. Improper waste management can have devastating effects on the environment and human health. Liberia and China are two countries that confront significant difficulties in managing their landfill waste. In Liberia, the absence of a legal framework for waste management is a significant barrier to the effective management of municipal solid refuse.

As a consequence, waste in Liberia is dumped carelessly on street corners and in bodies of water. Due to a lack of skilled technical human capacity, inadequate budgetary allocation for waste operations, and a lack of adequate waste minimization facilities, landfilling is the primary means of waste disposal in Liberia. The majority of China's solid refuse is disposed of in landfills. However, the management of landfill sites in China is frequently inadequate, with less than 20% of landfill methane collected and approximately 47% of landfill leachate untreated.

Challenges in Waste Management Both Liberia and China face significant waste management challenges. The absence of a legal framework for waste management in Liberia is a significant obstacle. Due to the absence of a legal framework, trash is dumped indiscriminately on street corners and in bodies of water.

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CHAPTER ONE
INTRODUCTION

The management of food waste has become a pressing global issue as populations continue to grow, leading to increased food consumption and subsequent waste generation. Landfilling Not only does food waste contribute to environmental degradation, but it also represents a lost opportunity for resource recovery and sustainable practices (Gaur et al., 2022). This research aims to conduct a comparative analysis between landfill food waste management in Liberia and China, two countries with distinct socio-economic contexts and waste management systems.

Liberia, a West African nation, has faced significant challenges in waste management due to years of civil war and limited resources. The consequences of inadequate waste management systems can be observed in the negative impacts on public health and the environment. Efforts have been made to address this issue through the launch of major sanitation campaigns, aiming to improve waste management practices and mitigate the adverse effects of landfill food waste (Lynch et al., 2020). One significant factor that distinguishes the landfill food waste management systems in Liberia and China is the cultural and socio-economic context in which they operate (Celestino et al., 2022).

China's rapid industrialization and urbanization have led to increased consumption patterns and the production of considerable quantities of waste. This has prompted the Chinese government to take proactive measures in waste management, emphasizing the importance of recycling and resource recovery (Cheng et al., 2022). In contrast, Liberia's waste management challenges are deeply intertwined with the country's post-war recovery and economic development. The limited resources and infrastructure in Liberia have posed considerable obstacles to establishing efficient landfill food waste management practices. By considering the socio-economic factors unique to each country, this research will shed light on the contextual influences on landfill food waste management approaches and outcomes.

On the other hand, China, a rapidly developing country with a massive population, has experienced unprecedented changes in waste management, including selective sorting and the ambition of achieving "zero waste." The Chinese government has enacted regulations that apply to promote waste sorting at the household level and has made significant strides in recycling systems. However, China also faces challenges, including high levels of soil, water, and air pollution associated with landfill food waste (Sharma et al., 2021). Furthermore, this comparative analysis will explore the potential impact of cultural and behavioral factors on landfill food waste management practices. Cultural norms, attitudes, and consumer behavior can significantly influence waste generation, sorting practices, and the overall effectiveness of waste management systems.

China's cultural emphasis on environmental responsibility and collective welfare has played a crucial role in shaping waste management practices, including household waste sorting (Wu et al., 2022). In contrast, Liberia's cultural dynamics, influenced by diverse ethnic groups and historical experiences, may present distinct challenges and opportunities for improving landfill food waste management (Townsend, 2019). Understanding these cultural nuances and their implications for waste management practices will provide valuable insights for tailoring strategies and interventions to specific socio-cultural contexts.

Moreover, this research will explore the regulatory frameworks governing landfill food waste management in both Liberia and China. The Chinese government has introduced comprehensive regulations and policies to enforce waste sorting and promote recycling, with a new regulation set to take effect on March 1, 2021 (Kurniawan et al., 2021). This emphasizes the significance of policy support and governance structures in driving effective waste management practices. In Liberia, the implementation of waste management policies and regulations has been influenced by the country's post-war recovery process, resource constraints, and capacity building challenges. Analyzing the regulatory frameworks in each country will provide insights into the institutional arrangements, policy enforcement mechanisms, and their impact on landfill food waste management outcomes.

Furthermore, the comparative analysis will delve into the specific challenges faced by Liberia in sustaining an efficient landfill food waste management system, taking into account the impact of years of civil war and the major sanitation campaigns launched in the country. Additionally, the repatriation of toxic waste from Liberia to Greece will be examined to understand its implications for landfill food waste management practices in Liberia. By comparing and contrasting the experiences and approaches of China and Liberia in landfill food waste management, this research aims to contribute to the development of sustainable waste management practices and give important information to policymakers, waste control authorities, and other interested parties in both countries. The findings of this study will help identify successful strategies, highlight areas for improvement, and foster knowledge exchange in the global pursuit of effective landfill food waste management.

- *Objectives*

Following are the objectives of current research:

- Compare the current state of landfill food waste management in China and Liberia, including the implementation of waste sorting initiatives, pollution levels, and overall effectiveness of the systems.

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- Investigate the historical development and lessons learned from household waste sorting practices in China, examining their applicability to improving landfill food waste management in Liberia.
- Assess the recycling systems in China and Liberia, focusing on the role of waste collectors and their impact on reducing landfill food waste.
- Examine the policies and perspectives of the Chinese and Liberian governments towards landfill food waste management, identifying successful approaches and areas for improvement in each country.
- Analyze the challenges faced by Liberia in maintaining a sustainable landfill food waste management system, considering factors such as the impact of civil war, major sanitation campaigns, and repatriation of toxic waste.

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CHAPTER TWO
METHODOLOGY

This research employs a comparative analysis methodology to examine and compare landfill food waste management practices between Liberia and China. The methodology involves several key steps to gather data, analyze the data, and draw comparisons between the two countries. The following sections outline the specific steps undertaken in this study to ensure a rigorous and systematic comparative analysis.

A. Data Collection

➢ *Literature Review*

A comprehensive literature review will be conducted to gather information on landfill food waste management practices, policies, and challenges in both Liberia and China. Academic journals, research articles, reports, and relevant policy documents will be examined to gain insights into the historical background, current practices, and issues related to landfill food waste management in each country. This step will provide a foundation for understanding the context and key factors influencing landfill food waste management in Liberia and China.

➢ *Data Sources*

Data from primary and secondary sources will be collected for the comparative analysis. Primary data will be collected through surveys administered to households and waste management authorities in selected regions of Liberia and China. The surveys will gather quantitative information on waste generation, disposal methods, waste sorting practices, and perceptions of waste management practices. Secondary data, including government reports, statistical data, and research studies, will be collected to supplement the survey data and provide a broader perspective on landfill food waste management in both countries.

B. Comparative Analysis

The comparative analysis will involve a systematic comparison of the findings from the quantitative and qualitative analyses conducted for Liberia and China. The similarities, differences, and trends observed in landfill food waste management practices, waste generation, disposal methods, and perceptions will be examined. Key factors contributing to effective or ineffective waste management in each country will be identified and discussed. The comparative analysis will highlight the strengths and weaknesses of landfill food waste management practices in Liberia and China, facilitating a comprehensive understanding of the similarities, differences, and lessons that can be learned from each context.

➢ *Steps for Comparative Analysis*

This research utilizes a comparative analysis methodology to examine and compare the existing literature on landfill food waste management practices in Liberia and China. The methodology involves several key steps to ensure a systematic and comprehensive analysis of the literature (Ben et al., 2018). The following sections outline the specific steps undertaken in this study to conduct the comparative analysis.

- *Research Questions:*

Clear research questions are formulated to guide the comparative analysis of the literature. These research questions address the specific aspects of landfill food waste management practices in Liberia and China that will be explored and compared. Examples of research questions may include:

- ✓ What are the regulatory frameworks and policies governing landfill food waste management in Liberia and China?
- ✓ What are the waste management practices and initiatives employed in both countries?
- ✓ How do public participation and awareness campaigns contribute to effective landfill food waste management in Liberia and China?
- ✓ What are the challenges and barriers faced in landfill food waste management in each country?

- *Literature Search:*

A comprehensive search of relevant literature is conducted. Academic databases, scholarly journals, research articles, reports, and policy documents are accessed to gather a diverse range of sources on landfill food waste management in Liberia and China. The literature search is conducted using keywords and specific search terms related to the research questions and the topic of interest.

- *Literature Selection:*

The identified literature is screened and selected based on relevance and quality. Relevant literature that provides insights into landfill food waste management practices in Liberia and China is included in the analysis. The selected literature should address key aspects such as waste generation, disposal methods, recycling initiatives, policy frameworks, public participation, and challenges specific to each country.

- *Data Extraction and Analysis:*

Data extraction involves systematically extracting key information from the selected literature. This includes relevant findings, methodologies, theoretical frameworks, and key arguments or discussions related to landfill food waste management in Liberia and China. The extracted data is organized and synthesized to identify commonalities, differences, and patterns in the literature.

- *Comparative Analysis:*

The comparative analysis involves examining and comparing the extracted data from the literature on landfill food waste management in Liberia and China. Themes, trends, and similarities are identified across the literature, allowing for a comprehensive understanding of the similarities and differences between the two countries. The comparative analysis focuses on the regulatory frameworks, waste management practices, public participation, challenges, and potential solutions in each context.

- *Synthesis and Interpretation:*

The findings from the comparative analysis are synthesized and interpreted to draw meaningful conclusions. The similarities, differences, and patterns identified in the literature are discussed in the context of landfill food waste management in Liberia and China. The synthesis aims to provide a comprehensive understanding of the current state, challenges, and potential opportunities for improvement in both countries.

C. Ethical Considerations

Ethical considerations were taken into account throughout the research process. The research will also comply with ethical guidelines and seek necessary approvals from relevant institutions to ensure ethical practices are followed.

By following this methodology, the research aims to provide a systematic and rigorous comparative analysis of landfill food waste management practices in Liberia and China. The combination of quantitative and qualitative data analysis will allow for a comprehensive understanding of the similarities, differences, and contextual factors that shape landfill food waste management in each country. The findings of this study will contribute to the knowledge base on effective waste management practices and inform policy recommendations for improving landfill food waste management in both Liberia and China.

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CHAPTER THREE
RESULTS AND COMPARISON OF TWO COUNTRIES

A. China

The problem of competent waste disposal is a global environmental problem that is acute for all mankind. As a result of the growth of production and consumption, there is an increasing amount of garbage waste, in addition, new varieties appear every year. Garbage is dangerous because the constant growth of its volume provokes:

- *Climate Change on the Planet;*
- *Water, Air and Soil Pollution;*
- *Death of Animals.*

Ecologists around the world are developing measures to combat the total problem of universal pollution, offering new ways to safely dispose and recycle waste.

The population of China places it in second place among all countries in the globe. Its economy has long been referred to as the "world factory", which can be explained by the gigantic volumes of both production and consumption. It is clear that China is one of the largest producers of waste in the world. The severity of the problem is increasing as the incomes of the population (and hence consumption), the pace of urbanization and the emergence of new agglomerations in the country grow (Chen et al., 2019).

Until 2017, China was just buried in garbage. Even in large cities - Beijing and Shanghai, there were many uncontrolled landfills, the rapid spread of which no one followed. Many residents simply dumped garbage where they could, and no one knew such a thing as separate waste collection in principle. Garbage companies could not cope with the work, and they could only transport waste from an uncontrolled landfill to a landfill and sometimes collect garbage from the streets (Pheakdey et al., 2022).

➢ *Waste Management: A Major Challenge for China*

From the 1980s, China began to import solid waste as a source of raw materials. These imports have made this country an indispensable player in the treatment of solid waste on an international scale. Today, the world's leading market for solid waste treatment is moving towards more ecological and environmentally friendly development.

Despite its limited recycling capabilities, China has been the world's largest importer of waste for years. In 2016, the country received 56% of the world's solid waste production, i.e., more than 7.3 million tons of plastic and more than 50 million tons of hazardous waste. In early 2018, with the adoption of a new environmental policy, China banned the import of 24 categories of solid waste, including certain types of plastics, unsorted paper, wood and textiles (Millati et al., 2019).

By 2020, China's annual municipal solid waste (MSW) production had surged to 235.12 million metric tons (Mt) (Figure 1). The global average annual MSW growth rate was 8.4%, which is comparatively lower than China's growth rate of 10% (Figure 2). In 2014, the MSW disposal rate rose to 91.8%, a notable increase from the 66.8% recorded in 2008. As MSW generation continues to rise each year, more than 25% of cities are struggling to find suitable waste disposal sites, while over 60% of cities face the challenge of waste management.

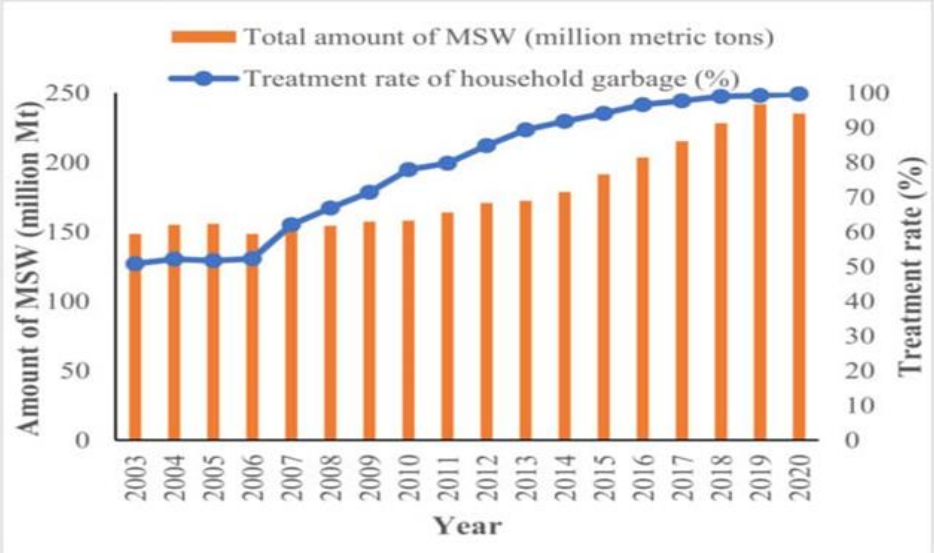

Fig 1 The Rate of Municipal Solid Waste (MSW) Generation and Disposal in China between 2003 and 2020
Source: Kurniawan et al. (2022).

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After the progressive ban on the import of solid waste by accumulative measures, the government finally decided on a total ban on imports. Since January 1, 2021, it is illegal to export solid waste to China, subject to heavy criminal and economic penalties. This government decision has destabilized the main waste-exporting countries which, like France and the United States, have directed their exports to other destinations. Following this decision, the least developed countries in the South-East Asia region experienced a substantial increase in their waste imports (Zhang, and Liu, 2023). It is with determination that some countries, such as Malaysia and Indonesia, have followed China's lead by also adopting restrictive measures to limit the quantity of solid waste imported.

At the same time, the Chinese government is massively tightening customs controls to intercept and seize the illegal import of solid waste into its territory. In 2020, Chinese customs seized several thousand tons of illegal waste and returned it to shippers.

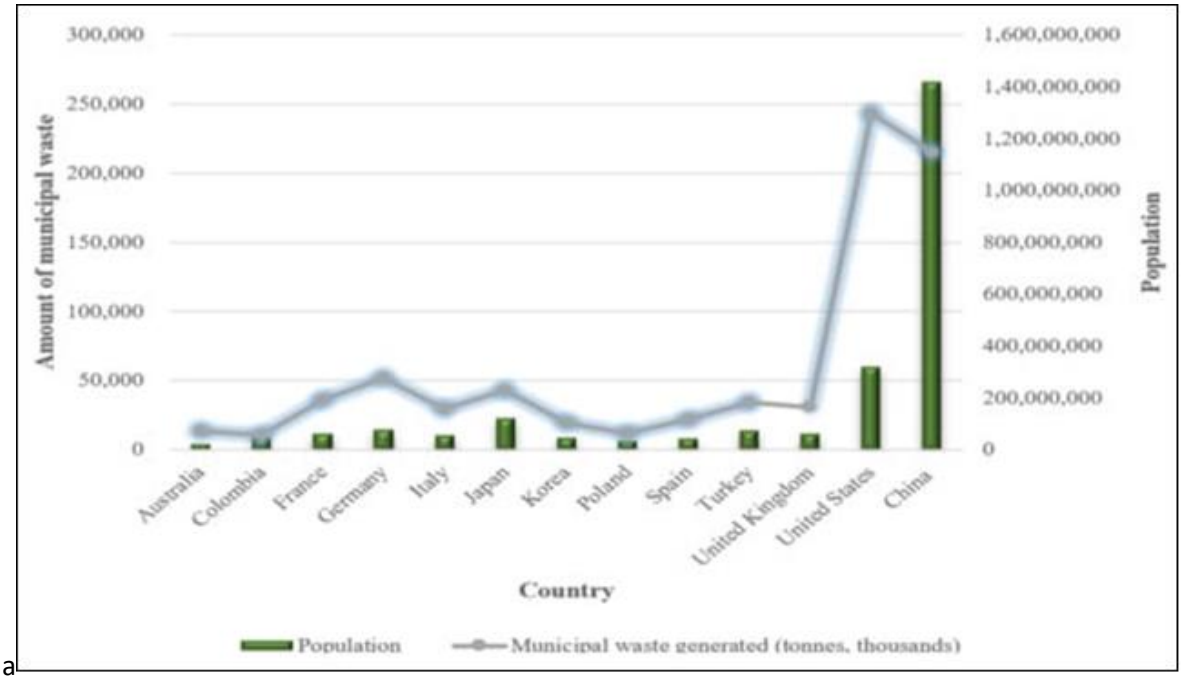

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Fig 2 Analysis of the Rate of Municipal Solid Waste (MSW) Expansion in China Relative to Other Nations
Source: Kurniawan et al. (2022)

➢ *An Unprecedented Change with the Arrival of Selective Sorting*

Environmental protection is one of the major issues at the heart of the Chinese government's concerns. The Ministry of Ecology and Environment of China (MEE) has set up three principles to conduct all actions and measures implemented in the field of waste management and treatment: reduction, recovery and environmentally friendly disposal. rational. With the strengthening of state oversight mechanisms and public pressure for environmental improvement, the waste sector is changing and will be an emerging market in the years to come.

China is currently concentrating on the environmental aspect of its development, in particular on the question of the treatment of household waste, and this involves raising awareness and training its 1.4 billion inhabitants in the selective sorting of their waste. According to data from the Ministry of Housing and Urban and Rural Construction (MOHURD), 237 cities have started to sort waste. Since July 2019, 46 key cities, i.e. 77 million households, have been selected for the implementation of selective sorting. With the objective of gradually generalizing the treatment and recovery of waste, the government wishes, by 2025, to introduce the selective sorting of household waste in total in more than 300 cities across the country (Wang and Jiang, 2020).

At the end of 2020, statistics were published on 46 test cities. Evidence suggests that the capacity for processing kitchen waste in these cities has almost doubled, from 34,700 t/d to 62,800 t/d, an increase of 28,100 tons compared to the average daily level recorded in 2019.

- *In Shanghai, a Test City, the Results are there with:*

✓ *A 71% Increase in Recyclable Waste Collected, Reaching 6,814 t/d*
✓ *An Increase of more than 39% in Wet Waste Collected (9,632 t/d)*
✓ *A 110% Increase in Hazardous Waste Collected (33,000 t/d)*

➢ *An Ambition Towards "Zero Waste"*

In line with its environmental policy, the Chinese government has selected 11 cities and 5 new pilot districts to develop "Zero Waste" cities (Lu et al., 2021).

- *11 cities: Shenzhen, Baotou, Tongling, Weihai, Chongqing, Shaoxing, Sanya, Xuchang, Xuzhou, Panjin, Xining*
- *5 districts: Xiong'an, Beijing Economic – Technological Development Area, Tianjin Eco City, Fujian Guangze, Jiangxi Rui'an*

In Shenzhen, for example, a selective sorting system has been deployed in 3,508 residences and 109 sorting stations throughout the city. A specific waste collection and processing system has been set up in Tongling, particularly for the collection of used mineral oils and hazardous waste. In addition, the National Development and Reform Commission and the Ministry of the Environment announced in January 2020 a five-year plan to reduce plastic consumption by 30% (Awasthi et al., 2021).

As early as 2008, the country took measures to prohibit free plastic bags and a total ban on plastic bags, straws, disposable cups to encourage the consumption of substitute products. And since January 1, 2021, in major cities, such as Beijing and Shanghai, merchants, restaurants, supermarkets and hotels no longer provide single-use plastic items. In addition, highly populated regions such as Beijing, Shanghai and Jiangsu Province will ban the use of non-biodegradable packaging from the end of 2022. With the aim of seeing a significant drop in the consumption of disposable plastic products, the production and the sale of plastic films and bags in agriculture will also be banned. The plan also calls on companies in the e-commerce sector - a big consumer of packaging - to reduce waste and disposable plastics (Lu et al., 2021).

➢ *China Reaches an Unprecedented Level of Soil, Water and Air Pollution*

According to the 2018 annual report of the Ministry of Ecology and Environment of China (MEE), the industrial solid waste generation volume reached 1.55 billion tons in the country's 200 major cities, including 46.4 million tons of hazardous industrial waste. For solid industrial waste, the recycling rate is 41.7% and 43.7% for hazardous industrial waste. In the desire to increase its recycling capacities, China has opted for the implementation of specific programs. The generation of medical waste in these cities is 817,000 tons per year. The medical waste treatment rate in the latter is 99.9% (Wang et al., 2021).

- *The Government has Reinforced its Actions by Adopting a Revision of the Law on Waste. the Changes Mainly Concern 10 Aspects:*

✓ Implementation of a management system to ensure the traceability of waste produced by manufacturers and collected, transported and treated by service providers;
✓ Clarification of the definition of solid waste;
✓ Adjustment of the list of hazardous waste;
✓ Clarification of the legal responsibility for the discharge of waste, the amount of the fines amounts to approximately 773,000 USD;
✓ Authorization for waste disposal by permit;
✓ Clarification of the legal responsibility of manufacturers of electronic products (domestic appliances, lead batteries, car batteries, etc.) regarding the recycling of used products;
✓ Clarification of the legal liability of operators of wastewater treatment plants for sludge treatment
✓ Improved construction waste management layout
✓ Addition of the mandatory provision on environmental insurance for companies collecting, storing, transporting, recycling and treating hazardous waste
✓ Added environmental and ecological damages rules

Thanks to all these revisions, it is expected that by 2030, the value of "urban mines" – reused recyclable rare metals – will reach 2,140 billion yuan (309.7 billion USD), the use of rural waste will generate 3,970 billion yuan (574.5 billion USD) and the economic gains generated by the recycling of industrial solid waste will reach more than 1,350 billion yuan (195.4 billion USD).

➢ *A New Regulation will Enter into Force on March 1, 2021*

As part of the improvement of environmental protection, Chinese Premier Li KEQIANG signed a decree of the State Council on regulations for the administration of pollutant discharge permits. All actors involved in the discharge of pollutants will have to submit to the permit application. The institutions or companies concerned will be classified for their management according to specific factors: the quantity of polluting emissions, the modes of discharge, the destinations of the pollutants and the impacts on the environment. They must set up self-monitoring systems and communicate information on polluting emissions to the Chinese authorities responsible for ecology and environmental protection.

Through the measures put in place, China's environmental ambition now offers new opportunities for companies specializing in the management and recovery of waste in the collection, sorting and recycling of household, construction and demolition waste. , hazardous and medical waste, electronics, batteries etc.

➢ *Sorting Household Waste in China*

Indeed, in 2017 the European Union exported 50% of its waste to China. This decision is in line with China's desire to strengthen the protection of its environment, the trade in various wastes, in particular hazardous waste, contributing to air, soil and water pollution. But how does waste sorting work in China, and in particular that of household waste sorting?

➢ *History of Household Waste Sorting in China*

Recycling regulations are mostly decided by city or province; however some regulations are nationwide.

- The first plan on recycling in China was promulgated in 2000 and concerned 8 cities including Beijing, Shanghai and Shenzhen;
- In March 2017, the *NDRC* (National Development and Reform Commission) and the *MOHURD* (Ministry of Housing and Urban-Rural Development) published the directive "The Implementation Plan of Garbage Sorting" which provides that 46 cities* must impose mandatory recycling of garbage. waste. The objective set is to achieve 35% recycling by 2020. To implement this plan, waste sorting must be institutionalized and residents must be trained in recycling.

➢ *Implementation of Sorting in China*

In China, about 210 million tons of household waste were produced in 2017 (with 22,000 tons and 26,000 tons of waste produced per day for Shanghai and Beijing respectively) and this figure could reach 500 million tons in 2030. In 2018, approximately 40% of the waste collected was landfilled, the rest being mostly incinerated.

- *Currently, the Chinese sort their Waste very Little for Various Reasons:*

✓ Lack of habit of this type of practice, which is often linked to the very absence of recycling bins;
✓ Moreover, even if there are possibilities for sorting, this is often done incorrectly or not, either because of a lack of knowledge of the practices to be implemented for sorting, or because of failure to take into account the instructions for sorting. Moreover, the contents of the different types of bins are often brought together a posteriori during collection by the municipal services, which does not encourage residents to sort.

According to a survey of 1,300 people by the "Policy Research Center for Environment and Economy" under the supervision of the *MEE*(Ministry of Ecology and Environment), only 30% of respondents believe they know how to sort their waste, while 90% of respondents are aware of the importance of recycling for environmental protection. Home delivery is also booming in China, producing the same amount of waste in one year as the city of Philadelphia. However, according to a survey by the state daily *Global Times* , 71.6% of people questioned about this type of consumption are not aware of the environmental consequences that result from it.

One of the major problems for the sorting of household waste is therefore to succeed in forming and changing the habits of the Chinese regarding sorting. Different methods have therefore been deployed in Chinese cities such as Xiamen, where waste sorting is taught in primary school. In Shanghai, various measures are implemented:

- Since mid-June 2018, in some districts of the city, volunteers and municipal employees have been helping residents sort their waste. Once the sorting is done, the inhabitant receives points which can later be converted into yuan to buy household products;
- The installation of 4 types of bins: wet waste (food), dry waste (residual), toxic waste and recyclable waste, coupled with a system of fines ranging from 50 to 200 yuan (around €25) for individuals who do not not recycle properly. However, this system is complex to set up because it is difficult to control. In addition, one of the objectives is to limit waste at source, for example by prohibiting hotels from providing disposable shower slippers and caps or by encouraging home delivery players to no longer systematically provide disposable chopsticks and forks (law adopted on January 31, 2019 which took effect on July 1, 2019). Since the law came into effect, some 30,000 volunteers have been deployed to oversee the segregation of waste.

The entry into force of these regulations in Shanghai has also led to the rise of many start-ups and mobile applications. Start-ups offer mobile applications ranging from help with sorting to sending staff to homes to sort and remove waste. In other cities, there are also "smart" bins that allow residents to earn money when they recycle waste. The amount of money collected is calculated according to the weight and type of waste (metal, paper, etc.) deposited.

China also has a unique recycling system: collectors. It is estimated that the number of collectors is around 160,000 for Beijing, and 10 million for China. Materials of all categories (plastics, metals, etc.) are thus collected and recycled. However, this recycling in precarious conditions is not always virtuous, because it is often carried out without consideration of the regulations. For example, one method used for recycling electrical cables consists of burning the plastic sheath in order to recover the metals. One of the challenges of recycling in China is to recognize and integrate these practices into a more virtuous recycling system that is aware of environmental issues.

➢ *Waste Recycling and Sorting in China: what Lessons does China Teach us*

It is not for nothing that China has embarked on a course of economic development and raising the standard of living of its citizens. Therefore, in March 2017, a Plan was published that introduces a system of mandatory sorting of garbage and household waste. It was a project that was jointly developed and supervised by various relevant ministries of the PRC.

- *At First, Things went slowly, which was Facilitated by two main Factors:*

✓ The lack of consciousness of citizens, many of whom (especially in remote areas) were generally illiterate;
✓ Insufficient logistics of the process of separate waste collection and its further processing, as an emerging direction.

In addition to the civilized collection of fresh garbage, it was also necessary to sort out the existing landfills, especially unauthorized ones, which means sorting out the waste accumulated randomly over the years.

In April 2020, with already three years of experience in optimizing the waste problem, China passed an important law providing for stricter measures to prevent and control solid waste pollution. By the end of the same year, almost 50 cities in the country had introduced and began to use mandatory waste sorting.

Of course, this cost the state significant investments. In the period 2017-2020, state budget expenditures amounted to about 25 billion euros, of which:

✓ 17 billion spent on the construction of processing and purification facilities;
✓ 2.5 billion invested in the development and implementation of a separate waste collection system;
✓ 2 billion subsidized in the processing of food waste and related projects.

Now in China, the 14th Five-Year Plan is in full swing (the planned economic and industrial period of development, which also existed in the USSR), by the end of which, in 2025, it is planned to strengthen and streamline the fight against garbage in every possible way. The government plans specific figures:

✓ Achieve an increase in the level of waste recycling up to 60%, while the indicator at the end of 2021 is no more than 40%;
✓ Ensure the incineration of at least 800 thousand tons of waste daily, while the indicator at the end of 2021 is no more than 600 thousand tons.

All these measures are aimed at improving the ecological situation in this densely populated country and improving the health of its inhabitants. And incineration of waste makes it possible to extract thermal energy necessary for the national economy.

But after all, only the construction of waste processing and incineration plants, as well as multi-colored containers on the street, is indispensable. A lot depends on the consciousness of the citizens themselves, and also on the marketing of certain types of production.

➢ *Energy from Garbage in China*

In previous years, waste in China was taken to landfills, where at first the garbage was buried, and then it was done only to the extent possible. In connection with the growth of the economy, the well-being of the population increased and at the same time the amount of waste increased. Currently, China produces 1.5 million tons of it daily.

Garbage landfills grew rapidly. There were no longer enough territories allocated for this burial. According to experts, 6 billion tons of household waste have accumulated on 20,000 hectares of land in Chinese cities today, the volume of which is growing by 5% annually.

➢ *Waste to Income*

At the end of the last century in China, due to the rapid increase in the amount of garbage, they began to seriously study the experience of European countries in waste incineration at specialized enterprises. The Chinese are developing this direction at a fairly rapid pace, using already created technologies. In the mid-eighties, the design and construction of one waste incineration plant took a lot of time and financial resources. Today the situation has changed radically. The process of recycling waste using energy-efficient technologies has accelerated noticeably.

Currently, there are 260 such enterprises in China, by the end of 2019 it is planned to increase their number to 500 units. As a result of burning garbage, its volume in China is annually reduced by 90%, and its weight by 70%.

Today, 40% of the country's waste is recycled at China's waste incineration plants, which is 200 million tons per year. In the next five years, this figure will increase to 60%.

B. Liberia

➢ *In Liberia, Waste Management, Health and the Environment are Paying the Price for Years of Civil War*

For years, Monrovia, the capital of Liberia, woke up every morning to a toxic blue haze emanating from burning garbage. Both the drainage network and the sewage system were in disrepair and filled with rubbish, which caused inundation of the rainy season and allowed mosquitoes and other disease vectors to breed (David et al., 2020). The inhabitants somehow survived by burning their burying or discarding refuse anywhere. Numerous localities have ended up putting their trash to good utilize land restoration, with open dumps filling in swamp areas and widening stream banks. It is estimated that the city's most visible rubbish piles alone made over 70,000 tons of trash.

In 2005, this was the case in the city of Monrovia. where nearly 1 million individuals resided through all of the civil war that lasted years without a structured system of garbage collection and disposal. The accumulation of solid waste has had major consequences for the health of the residents and the condition of the environment: contamination of rivers and lakes and drinking water sources, exponential increase in cases of disease as well as infection rates. In 2005, UNICEF recorded over 26,650 cases of cholera. (Clark-Ginsberg et al., 2022). When the conflict was over, a few large spontaneous sanitation initiatives led by the UN, UNICEF, NGOs and the municipality made it possible to collect and eliminate some of the garbage strewn around the municipality. But they kept piling up and in the lack of a collection system, the garbage piles quickly reappeared.

➢ *Launch of a Major Sanitation Campaign*

Things really started to change in April 2007. At the request of the Liberian government, the World Bank launched an ambitious project on that date to resuscitate a rudimentary solid waste collection system for the municipality of Monrovia. The stakes were high, with the municipal company in charge of solid waste collection having virtually no capacity to fulfill its responsibilities. It had only two working trucks, and its annual budget was about $500,000, one-eighth of a city comparable in size to Monrovia.

The World Bank-funded project began with a massive garbage dump clean-up effort led by local contractors. It also set up a regular collection system, and resulted in the purchase of 120 dumpsters and eight dump trucks for the municipality. The dumpsters were placed in community collection centers scattered throughout the city, and the collection service was contracted out to local businesses, which use the municipality's trucks to collect and empty these dumpsters from neighborhoods (Birch, 2021).

This service is still in place today, and collects approximately 30% of the waste produced each day in the city. It has so far enabled the collection and disposal of nearly 80,000 tons of waste, which has transformed the appearance of Monrovia and dramatically improved the living environment of its inhabitants. The term “liberating” is the term used by Felicia Jubah, a resident of Monrovia, to describe the impact of the project. *“Finally, we no longer need to live among our filth. The streets of Monrovia are cleaner, and we are beginning to feel proud of our city…”*

➢ *Challenges Ahead to Sustain the System*

Waste disposal raised its own set of problems. The Fiamah landfill, which already existed before the project, was poorly managed and located very close to a residential area, which presented significant health and environmental risks. On a provisional basis, the project financed a component for the rehabilitation and improvement of the management of this site. But a more suitable location for a temporary landfill was found at the same time in Whein Town, and is now being developed as part of the project (Bundhoo, 2018).

“This project is the first step in a long process,” explained Bronwyn Grieve, consultant to the Bank. *“The challenge right now is not just to further develop the system, but to address the broader systemic issues around how the system will be sustained following World Bank funding. »*

Establishing a large-scale and sustainable garbage collection system in Monrovia presents significant challenges for the future. Innovative solutions will have to be found for the recovery of the costs associated with the disposal of solid waste in a city with limited resources and where, in addition, a large segment of the population is unemployed and lives in makeshift dwellings, which makes it little or not able to pay the costs of household waste.

Reform and capacity building within the municipality, as well as the identification and development of a site for a permanent landfill, are also high on the list of priorities for the establishment of an effective disposal system. solid waste management. But despite these challenges, the restoration of an essential public service after 14 years of war has helped to strengthen civic spirit and restored the population's confidence in its municipal leaders. Encouraged by the support of its people, the municipality is now seeking additional support from the World Bank and other donors to be better able to provide services to its citizens. As for the Bank, encouraged by the admittedly modest but promising results of this emergency project, it remains determined to support the Municipality of Monrovia in its efforts to develop, modernize and deliver public services. For her, the work is not finished.

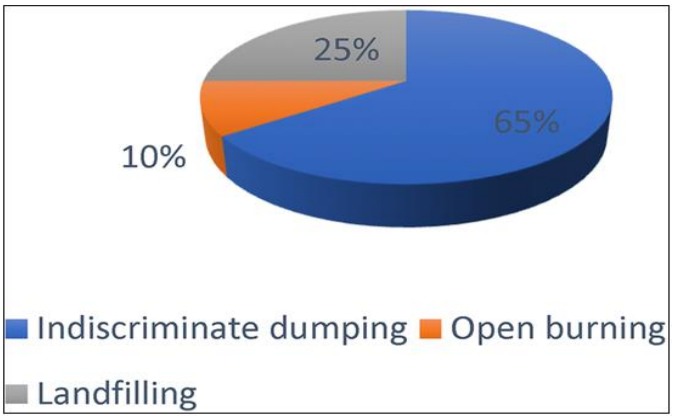

Fig 3
Source: David et al., (2020).

➢ *LIBERIA: Authorities Repatriate a Shipment of Toxic Waste to Greece*

Authorities from the Liberian Environmental Protection Agency (EPA) ordered the return of four containers to their sender. The shipment from Greece had been smuggled into Liberia, while it contained chemical waste hazardous to health and the environment (Gantus, 2019). Liberia refuses to become the dumping ground for toxic waste produced by developed countries. On January 2, 2020, the Port of Monrovia Anti-Contraband Unit quarantined four 40ft containers. And this after noticing that an unusual and nauseating odor emanated from these containers from Greece, which had been illegally brought into Liberia by Republic Waste Services, an American waste management company.

C. *Comparison between 2 Countries*

In Liberia, after a civil war that lasted several decades, the capital, Monrovia, is an open dump. Garbage invades roads, canals and waterways. The World Bank started in 2010 to help this city to manage its solid waste, within the framework of an emergency intervention which had as a main objective to improve the financial management, the public markets, the management of the contracts and the collection costs. A controlled landfill and two garbage transfer centers have been built, illegal dumps have been destroyed and the waste removal rate has been increased from 13% to 50%.

In China, the volume of solid waste collected in cities has increased significantly, from 31 million tons in 1980 to 157 million in 2009, and is expected to reach 585 million tons in 2030 due to rampant urbanization and unprecedented demographic expansion. The World Bank is financing a new solid waste management project in Ningbo (a). This involves setting up a system for separating the household waste produced by more than 2 million inhabitants and setting up a public-private partnership to finance the construction of a plant that will process food waste produced by households and in public places.

Liberia and China present intriguing cases for a comparative analysis of landfill food waste management. This examination aims to shed light on the similarities, differences, and lessons that can be learned from their respective approaches. The following discussion delves into key aspects of comparison, including regulatory frameworks, waste management practices, public participation, and challenges faced in landfill food waste management.

In terms of regulatory frameworks, there is a notable contrast between Liberia and China. Liberia, having endured years of civil war, has struggled with a lack of robust waste management infrastructure and regulations. However, recent efforts, such as the launch of a major sanitation campaign, indicate a growing acknowledgment of the importance of waste management in the country. On the other hand, China has experienced a significant paradigm shift in recent years. With the introduction of selective sorting and an ambitious goal of achieving "zero waste," the Chinese government has implemented regulations to enforce waste sorting practices and promote recycling.

Waste management practices in Liberia and China also demonstrate significant disparities. In Liberia, limited resources and infrastructure have hindered effective waste management systems. Landfills are often the primary method of waste disposal, with minimal recycling or composting initiatives in place. In contrast, China has made substantial progress in waste management practices. The implementation of waste sorting systems has allowed for the effective separation of different waste streams, contributing to increased recycling rates and reduced reliance on landfills.

Public participation plays a crucial role in landfill food waste management, and both countries exhibit distinct levels of engagement. In Liberia, public awareness and participation are still relatively low due to limited education and outreach programs. There is a need for increased community involvement and empowerment to foster behavioral changes towards waste reduction and proper disposal. In contrast, China has implemented extensive public awareness campaigns, emphasizing the importance of waste sorting and recycling. The Chinese government has also introduced incentive systems to encourage active public participation in waste management initiatives.

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Challenges faced in landfill food waste management differ between Liberia and China. Liberia encounters obstacles such as limited funding, inadequate infrastructure, and a lack of waste management facilities. These challenges stem from the aftermath of civil war and ongoing economic constraints. In contrast, China faces issues related to the scale of waste generation in densely populated urban areas. Despite significant progress, China's rapid urbanization and consumption patterns have posed challenges in managing large quantities of waste effectively. Balancing waste management needs with sustainable development remains a key challenge for the Chinese government.

The comparative analysis of landfill food waste management between Liberia and China provides valuable insights into the contrasting approaches, challenges, and potential solutions in each country. Liberia's post-war context and limited resources have created unique obstacles, while China's ambitious goals and significant progress highlight the potential for effective waste management practices. By understanding the similarities and differences between these two countries, policymakers and stakeholders can identify strategies and lessons that can be adapted to improve landfill food waste management practices worldwide.

The following table offers a more thorough review of the landfill food waste management conditions in China and Liberia, including legislative frameworks, waste management procedures, public involvement, difficulties, and creative solutions.

Table 1 Comparison between Liberia and China

Aspect	**Liberia**	**China**
Regulatory Frameworks	Limited waste management infrastructure and regulations	Implementation of waste sorting regulations
	Recent efforts to improve sanitation and waste management	Ambitious goals of achieving "zero waste"
Waste Management Practices	Reliance on landfills with minimal recycling or composting	Waste sorting systems, increased recycling rates
	Limited resources and infrastructure for waste management	Emphasis on waste-to-energy plants
Public Participation	Relatively low public awareness and participation	Extensive public awareness campaigns, incentive systems
	Limited education and outreach programs	Incentives for proper waste sorting and participation
Challenges	Limited funding, inadequate infrastructure, lack of facilities	Managing large quantities of waste in urban areas
	Aftermath of civil war and ongoing economic constraints	Rapid urbanization and consumption patterns
Innovative Approaches	Major sanitation campaign, construction of controlled landfill and transfer centers	World Bank-financed projects for waste separation and food waste processing
	Destruction of illegal dumps, increased waste removal rate	Emphasis on public-private partnerships and sustainability

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CHAPTER FOUR
CONCLUSION

In conclusion, Liberia faces significant challenges in landfill food waste management due to the aftermath of civil war, limited resources, and inadequate infrastructure. The country has made efforts to address these issues through the launch of a major sanitation campaign, reflecting a growing recognition of the importance of waste management. However, there is a need for increased investment, education, and community engagement to overcome the existing barriers and develop sustainable waste management practices. Liberia can draw lessons from other countries, including China, to explore innovative approaches and strategies that can be tailored to its specific context. By prioritizing waste management and implementing effective policies and infrastructure, Liberia can strive towards a more environmentally sustainable future.

It is still too early to conclude on a positive or negative assessment of the Chinese measures. For good reason, the issue of the consequences of our productivism and consumerist lifestyles goes far beyond our ability to manage our waste. What is certain is that they have disrupted the global circular economy, and that they have drawn the attention of decision-makers to the way we manage our waste. At a time when the World Bank predicts that the amount of waste produced by the planet will increase by another 70% in the next 30 years, it is imperative that developed countries seize this opportunity to begin a real restructuring of the economy. world, from production to consumption.

- *Future Recommendations*

For future research on landfill food waste management in Liberia, the following recommendations are suggested:

- Quantitative Assessment of Food Waste: Conduct a comprehensive quantitative assessment to estimate the quantity and composition of food waste generated in different sectors and regions of Liberia. This would provide a baseline understanding of the magnitude of the problem and help identify priority areas for intervention and waste reduction strategies.
- Socio-economic Analysis: Explore the socio-economic factors influencing food waste generation and management practices in Liberia. Investigate the impact of income levels, household size, and cultural attitudes towards food consumption and disposal on the generation and disposal of food waste. Such analysis can inform targeted interventions and behavior change campaigns.
- Evaluation of Existing Interventions: Evaluate the effectiveness of ongoing interventions and initiatives aimed at reducing landfill food waste in Liberia. Assess the impact of awareness campaigns, recycling programs, and waste management infrastructure projects on waste reduction, recycling rates, and environmental outcomes. Identify success factors and challenges to inform future interventions.
- Technological Innovations: Investigate emerging technologies and innovative approaches in landfill food waste management. Explore options such as anaerobic digestion, vermicomposting, and bioenergy generation from food waste. Assess the feasibility, scalability, and potential benefits of adopting these technologies in the Liberian context.
- Stakeholder Engagement and Participation: Investigate the role of stakeholders, including government agencies, non-governmental organizations, private sector actors, and communities, in landfill food waste management. Examine their level of engagement, coordination, and collaboration in implementing waste management initiatives. Identify strategies to enhance stakeholder participation and cooperation for effective waste management practices.

By addressing these research gaps, future studies can contribute to evidence-based decision-making and the development of effective strategies for landfill food waste management in Liberia. This research can support the country's efforts in achieving sustainable waste management practices, reducing environmental pollution, and promoting a circular economy approach to waste management.

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