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Food and Waste in Urban Kabul: The Role of the Informal Waste Sector and Climate Change

Bibi Khadija Ghanizada
Bard College

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by

Bibi Khadija Ghanizada

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Dedication

To the light of my heart, my mother jan, to my father who inspired me to become an urban planner and to my beautiful sister and my two younger brothers.

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Abstract

This thesis is a case study and policy proposal that focuses on implementing composting in urban Kabul, Afghanistan. The project is inspired by the desire to make the city more environmentally and economically sustainable, and to improve the living conditions and provide income opportunities for people working in the informal sector. The research explores the food and garbage locations in Kabul to find the intersections between the two and implement compost systems to prevent food waste being dumped in landfills. Through Geographic Information Systems (GIS) analyses, potential localized compost systems to mitigate the problem of food waste in Kabul city are identified. The goal of the project is to decrease the amount of food waste ending up in the waste system, and therefore decrease air pollution, water contamination, and public health risks in Kabul. Solid waste management system in Kabul also contribute to climate change by producing greenhouse gases. Therefore, the reduction of food waste will also help mitigate climate change. Finally, the project aims to create data necessary to help solve the problems that exist within the food and waste systems in the developing city of Kabul.

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Chapter 1

Goals and Aspirations of this Thesis

1.1 Compost at a Cucumber Farm in Urban Kabul

In the summer of 2019, after graduating from high school, I returned to my hometown of Kabul, Afghanistan to work on a compost project supported by the Afghan Students Financial Assistance group. With a longstanding interest in environmental issues and climate change, I chose composting as my project focus, intrigued by its innovative potential. While in Kabul, I met Professor Mohammad Daud, a Kabul University soil specialist and co-owner of a cucumber farm, who introduced me to worm composting. With his help, I successfully implemented and taught worm composting to the students at Mezan International School as part of the project, and it ran smoothly for a year until political instability and the COVID-19 pandemic struck Kabul.

Despite the chaotic situation in Afghanistan after the U.S. withdrawal of troops and the fall of the country to the Taliban in August 2021, I was determined to find a way to stay connected to my home city for my senior project. I had previously taken the Developing Cities course in my junior year, where I focused on Kabul and conducted a literature review of the city's waste infrastructure and solid waste management system. As a child, I had witnessed the piles of garbage on the streets of Kabul, and I was eager to explore ways to address this pressing issue.

My senior project was inspired by a paper on climate change and food systems by Professor Monika Zurek of Oxford University, which led me to focus on the food system in Kabul. The project aims to improve the city's food access and waste management, making it more resilient, environmentally and economically sustainable, and improving living conditions while providing income opportunities for the informal sector. The policy proposal was informed by Kabul's political, social, economic, and environmental context, taking into account Afghanistan's decades-long conflict and political instability under the Taliban. In recognition of the government's lack of resources and stability to address the solid waste management system, the proposal suggests that areas with a stronger economic background provide financial support, while areas with a weaker economic background contribute skilled labor.

1.2 Project Goals in Kabul City

This project aims to explore the intersections between the locations of food and garbage in Kabul and implement composting systems to prevent food waste from ending up in landfills. According to Ahmad Rashid Khoshbeen's *Integrated Solid-Waste Management for Kabul City, Afghanistan*, 54.2 percent

of food waste and biodegradable materials in Kabul's solid waste management system could be prevented from ending up in landfills through composting.[1]

Solid waste management has been a prominent problem in Kabul. The municipality relies on landfilling and open burning methods for garbage treatment, which results in various environmental and social consequences. Landfilling and open burning methods pollute the air close to residential areas and cause public health risks. Open burning of waste is responsible for 32 percent of air pollution in Kabul.[2] The untreated garbage also produces methane (CH4) and carbon dioxide (CO2), which are the two largest greenhouse gases (GHG) contributing to global warming and climate change.[3]

To develop policy proposals to address problems in the food system, it is essential to understand the system's production, transportation, and storage of food waste. I utilized Geographic Information Systems (GIS) to map and analyze the food and garbage access points in the main streets of central Kabul. The project aims to identify potential localized compost systems to mitigate the problem of food waste using GIS analyses. Composting food waste in Kabul will decrease the amount of food waste in the waste system and reduce the amount of garbage in piles, bins, and landfills. This, in turn, will help reduce air pollution, water contamination, and public health risks.

The project's main aspiration was to create the data I wished to see in the world. Due to more than 40 years of war in Afghanistan, opportunities for

1. Abdul Wahid Amiri, June-ichiro Giorgos Tsutsumi, and Ryo Nakamatsu, "A Case Study of Fukuoka Landfill Method and Environmental Impact Assessment of Solid Waste Management in Kabul City," 4, no. 4 (2016): 47.

2. Amiri, Tsutsumi, and Nakamatsu, 47.

3. Valérie Masson-Delmotte, Panmao Zhai, and Anna Pirani, *Climate change 2021: the physical science basis : summary for policymakers : working group I contribution to the sixth Assessment report of the Intergovernmental Panel on Climate Change*, OCLC: 1353287322 (Geneva, Switzerland: IPCC, 2021), 11–13.

conducting complex academic research projects have been limited. Therefore, it was necessary to collect primary data for the project. As I was unable to travel to Afghanistan due to safety concerns, I secured funding for a data collection team in Kabul, and 5,000 observations were made during the months of October and November 2022.

The next chapter will provide general remarks on climate change, solid waste management systems in developing cities, the informal waste sector, and the role the informal sector plays in mitigating climate change.

Chapter 2

Motivations of this Thesis

2.1 Climate Change and Solid Waste Management System in Developing Cities

Climate change is one of the biggest problems the world is attempting to tackle today. Humans activities contribute to most of the detected changes in the climate. The Intergovernmental Panel on Climate Change (IPCC) explains at least three changes in the Earth system. First is hot extremes which are caused due to greenhouse gases and the greenhouse gas effect. The second is heavy precipitation because of the change in the global water cycle with warmer temperatures. The atmosphere can hold more water and due to that more and faster evaporation is taking place and therefore resulting in heavier precipitation. The third is drought because the hot extremes create more wildfires.[1]

According to *A Case Study of Fukuoka Landfill Method and Environmental*

1. Masson-Delmotte, Zhai, and Pirani, *Climate change 2021*, 11–13.

Impact Assessment of Solid Waste Management in Kabul City by Abdul Wahid Amiri more than half (54.2 percent) of the waste generated in Kabul consists of food and biodegradable materials.[2] This is a significant concern as food waste is a major contributor to greenhouse gas (GHG) emissions. In fact, if food waste were a country, it would rank third in GHG emissions after China and the United States, accounting for 6 percent of total emissions.[3] If everyone stopped wasting food, it is estimated that 6-8 percent of human-caused GHG emissions could be reduced.[4] Additionally, 26 percent of total GHG emissions come from food production.[5] One of the most promising solutions to address these issues is composting, which can involve aerobic or anaerobic decomposition processes to recycle biodegradable materials like food waste. Composting could prevent the 54.2 percent of food waste and biodegradable materials in Kabul's solid waste management system from ending up in landfills or being openly burned.

This paper focuses on one climate change mitigation strategy: the issue of solid waste management in developing cities and the role the informal sector plays in creating an environmentally-friendly waste management system. The solid waste management system structure in developing countries contributes to climate change by producing carbon dioxide and methane. They are the two most important greenhouse gases and are the leading causes of global warming. This paper's goal is to mitigate the issues of climate change and the informal waste sector by analysing and proposing policies on how the informal waste sector can help mitigate climate change.

2. Amiri, Tsutsumi, and Nakamatsu, "A Case Study of Fukuoka Landfill Method and Environmental Impact Assessment of Solid Waste Management in Kabul City," 47.

3. "Food production is responsible for one-quarter of the world's greenhouse gas emissions," Our World in Data, accessed May 15, 2022, https://ourworldindata.org/food-ghg-emissions.

4. "Food production is responsible for one-quarter of the world's greenhouse gas emissions."

5. "Food production is responsible for one-quarter of the world's greenhouse gas emissions."

2.2 Solid Waste Management System and the Informal Waste Sector in Developing Cities

Solid waste management is a significant problem worldwide, particularly in cities. In 2016, cities worldwide generated 2.01 billion tons of solid waste, and this crisis is being exacerbated by rapid urbanization and population growth.[6] It is projected that waste generation will increase by 70 percent to 3.40 billion tons by 2050.[7] Many developing cities lack a solid waste management system that supports the waste life cycle, which includes generation, collection and transportation, treatment, and disposal. Sean Fox and Tom Goodfellow in the book note *Cities and Development* note that the waste management system is often ignored in favor of the water and sanitation systems, which are considered more important for a healthy and dignified life. However, neglecting the waste system affects both the water and sanitation systems by closing the drains and sewers, contaminating the water supply, and creating diseases.[8]

In developing cities, 90 percent of waste is dumped in unregulated dumps or openly burned, leading to severe health and environmental consequences such as methane and carbon dioxide generation.[9] Installing a proper waste management system is essential but extremely challenging and expensive, requiring a state to spend 20 to 30 percent of their municipal budget.[10] The focus of this research is Kabul, the capital of Afghanistan, with the aim of bringing Kabul into a dialogue with other cities to learn from them, analyze

6. "Solid Waste Management," World Bank, accessed March 17, 2022, https://www.worldbank.org/en/topic/urbandevelopment/brief/solid-waste-management.

7. "Solid Waste Management."

8. Sean Fox, Tom Goodfellow, and Jo Beall, *Cities and development*, Second edition, Routledge perspectives on development (London ; Routledge, Taylor & Francis Group, 2016), 150.

9. "Solid Waste Management."

10. "Solid Waste Management."

data collected from Kabul, and explore potential solutions.

According to Fox and Goodfellow in their book *Cities and Development*, the term informal sector, also known as the "informal economy," was first introduced by Keith Hart in 1971. The authors define the informal sector as "those economic activities that circumvent costs and are excluded from the benefits and rights incorporated in the laws and administrative rules covering property relationships, commercial licensing, labor contracts, taxes, financial credit, and social security systems."[11] In a less technical sense, the informal sector refers to communities that live outside of the formal infrastructure, such as people living in slums or tents in Kabul who are considered informal settlers.

The informal sector plays a complex role in the waste management system of developing cities. On the one hand, the informal sector contributes to waste issues, and on the other hand, they see waste as a resource and help mitigate it. In many developing cities, particularly in Asia, such as Lahore, Pakistan and Delhi, India, the informal sector is involved in waste collection and processing. This research will explore the intersection of food supply and garbage dumps to identify potential compost bin and facility locations that can steer Kabul towards a sustainable future, both environmentally and economically. It will also address the question of whether waste management can work in developing cities without involving the informal sector.

The next chapter will provide more information about Kabul, including its solid waste management system, a comparison with other developing cities, the role of the informal waste sector, and ways to formalize the informal sector to address waste issues.

11. Fox, Goodfellow, and Beall, *Cities and development*, 122–123.

Chapter 3

Current State of Solid Waste Management in Kabul City

3.1 About Kabul City

Kabul is the capital of Afghanistan with an area of 397 mi^2. It is the fifth fastest-growing city in the world.[1] According to a 2020 article on integrated solid-waste management for Kabul City, the city's population is currently around 5 million people, which is extremely dense for a confined area like Kabul.[2] The city generates 3050 tonnes of solid waste every day according to data shown in 2018.[3] There have been many studies done to suggest a

1. Sune Engel Rasmussen, "Kabul – the fifth fastest growing city in the world – is bursting at the seams," *The Guardian*, December 11, 2014, accessed March 17, 2022, https://www.theguardian.com/cities/2014/dec/11/kabul-afghanistan-fifth-fastest-growing-city-world-rapid-urbanisation.

2. Ahmad Rashid Khoshbeen, Mohanakrishnan Logan, and Chettiyappan Visvanathan, "Integrated solid-waste management for Kabul city, Afghanistan," Company: Springer Distributor: Springer Institution: Springer Label: Springer Number: 1 Publisher: Springer Japan, *Journal of Material Cycles and Waste Management* 22, no. 1 (January 1, 2020): 240–53, accessed April 9, 2022, https://link.springer.com/article/10.1007/s10163-019-00936-z.

3. Khoshbeen, Logan, and Visvanathan, 240–53.

paradigm shift from a business-as-usual scenario to an Integrated Solid Waste Management approach (ISWM). For example, the cost of this system in the case of Kabul will be 2210 million Afs per year which is to put it in perspective 24 million dollars.[4] However, based on the case study and data analysis, the city could reduce the cost to 1505.9 million Afs per year, which is 16 million dollars, if 25 percent of the waste was reduced due to reduced collection, transport, and disposal costs.[5] This chapter focuses on solutions for the current waste system in Kabul drawing examples from other Asian developing countries such as India, Pakistan, and Philippines.

The waste management system in Kabul is dependent on landfilling and open burning methods, which pollute the air.[6] 32 percent of air pollution, which is horrific, is due to the open burning of the waste.[7]The landfilling method is used because of it is simplicity and versatility, which creates untreated garbage and leachate problems. There are no legal enforcement or incentive policies for residents to practice waste prevention or source separation. There is also no incineration system or recycling factory.[8] The lack of infrastructure has caused the formation of the informal sector outside the formal infrastructure.[9]The open dumpsites are one example of the lack of infrastructure in Kabul. Currently, the way the waste system works in Kabul is that residents discharge their waste in landfills, open dumpsites, and solid waste collection points.As mentioned, urbanization and population growth have increased the demand for the expansion of the dumpsites and more burning in the city.[10]

4. Khoshbeen, Logan, and Visvanathan, "Integrated solid-waste management for Kabul city, Afghanistan," 240–53.
5. Khoshbeen, Logan, and Visvanathan, 240–53.
6. Khoshbeen, Logan, and Visvanathan, 240–53.
7. Amiri, Tsutsumi, and Nakamatsu, "A Case Study of Fukuoka Landfill Method and Environmental Impact Assessment of Solid Waste Management in Kabul City," 47.
8. Amiri, Tsutsumi, and Nakamatsu, 46.
9. Fox, Goodfellow, and Beall, *Cities and development*, 122–123.
10. Amiri, Tsutsumi, and Nakamatsu, "A Case Study of Fukuoka Landfill Method and

The informal settlements also create waste in Kabul City. Currently, in the city of Kabul, specifically in the 3rd district, which is a central district, 80 percent of the population lives in informal settlements that take up to 70 percent of the land area in the city. Basically, most of the city consists of informal settlements.[11]The informal settlements in Kabul are located on hills and narrow streets, which, in turn, become neglected because the municipality vehicles cannot access these locations.[12]They also burn a lot of materials that they have scavenged from the waste bins or on the streets during the harsh months of winter.[13]This open burning of the waste materials creates a huge public health problem, such as air pollution, as well as releases two of the most potent GHG, CH4 and CO2 dioxide, which contribute to climate change.

Environmental Impact Assessment of Solid Waste Management in Kabul City," 47.

11. Stefan Schütte, "The Informal (in)security in urban Afghanistan," *Iranian studies*, 2009, 470.

12. Amiri, Tsutsumi, and Nakamatsu, "A Case Study of Fukuoka Landfill Method and Environmental Impact Assessment of Solid Waste Management in Kabul City," 46.

13. Schütte, "The Informal (in)security in urban Afghanistan," 471.

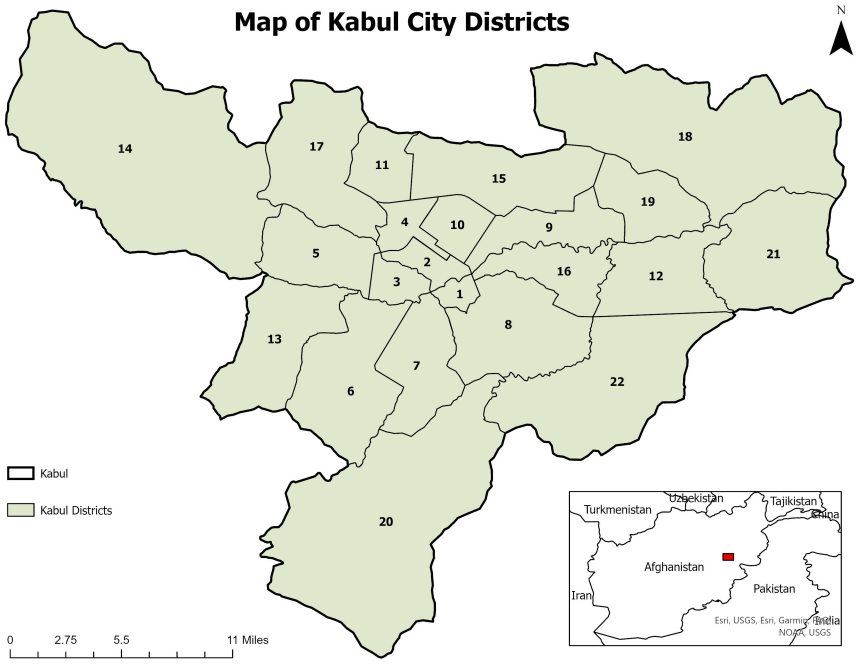

Figure 3.1: The city of Kabul is divided into 22 districts, with the first district comprising the city center, also known as the old city. The new city area, or Shar-i-naw neighborhood, is located in districts 2 and 4. The popular Shar-i-naw park and Chicken Street, renowned for its traditional Afghan clothing, jewelry, and carpets, are also situated in this area. District 4 is a more urbanized area, featuring tall apartment buildings and modern houses.The Chamatala Landfill, which serves as the main landfill in Kabul, is located in district 17 to the north of the city. The Directorate of Sanitation is situated in district 4, while the Agricultural Faculty of Kabul University is in district 3. The Kamyab Waste Management service, a private waste management service, is located in district 15, and the collection points for segregated waste are located in Makroyan, an area within district 16 of Kabul.[15]

3.2 A Comparison Between Kabul and Other Developing Cities

3.2.1 The Role of the Informal Waste Sector

The informal sector plays a rather complex role in the waste management system in developing cities. In their book *Cities and Development*, Fox and Goodfellow discuss how the informal sector in developing countries is investing in its own resilience programs in response to climate change.[16]At the same time they mention the role the informal sector plays in waste management and how that helps mitigate climate change. Chandra Bhushan Kumar in his article *Climate Change and Asian Cities:So Near Yet So Far* mentions how in Asian countries the informal sector working in solid waste management and recycling make their livelihoods from this work as well as help reduce the carbon emissions.[17] In most developing cities especially in Asia such as Lahore, Pakistan and Delhi, India the informal sector is used for waste collections and the waste processing. For instance looking into Samanabad which is a northern town of Lahore the waste system utilizes the informal sector for waste collection which the city of Kabul does as well but could benefit from how the informal waste sector functions in Samanabad since Pakistan is a neighboring country of Afghanistan with many cultural and infrastructural similarities. Kabul can learn and implement the methods of how Samanabad has integrated the informal sector in their solid waste management system.

Samanabad is a small town in Lahore with the population of 1,231,497 and 164,110 houses.[18] The Lahore Waste Management Company is responsible for

16. Fox, Goodfellow, and Beall, *Cities and development*, 197.

17. Chandra Bhushan Kumar, "Climate Change and Asian Cities : So Near Yet So Far," *Urban Studies* 50, no. 7 (May 1, 2013): 1456–1468.

18. Syeda Amber Fatima, Mohammad Nawaz Chaudhry, and Syeda Adila Batool, "Envi-

overseeing the waste system in the city. As of 2018, the waste generation rate in Lahore was 0.63 kilograms per capita per day (kg/c/d), which is almost equivalent to the amount of waste produced by the residents of Kabul. To provide a comparison of waste generation rates between the two cities, the waste generation rate in Lahore (0.63 kg/c/d) is nearly equivalent to that of Kabul (0.61 kg/c/d). To arrive at this figure, the waste generation rate in Kabul was calculated by dividing the city's daily waste generation of 3050 tons by its 5 million residents. This resulted in a figure of 0.00061 tons of waste per capita per day, which translates to 0.61 kilograms per capita per day (kg/c/d) when converted. This waste generation similarity between Kabul and Samanabad makes the case study more useful.

At the same time similar to Kabul, Samanabad also has uncollected waste. For instance, 30 percent of the waste is left uncollected in open dumps. 66 percent of the waste is organic waste, while 25 percent is recyclables and 9 percent is miscellaneous waste. The informal sector plays an important role in recycling. 41 percent of the recyclables are sold to junk shops by households and 28 percent of them are sorted out by scavengers at the dumpsites.[19] Junk shops connect the informal waste sector with the waste management sector which is a program that can be implemented rigorously in Kabul's waste system. In Lahore there are two types of junk shops: there are small junk shops in residential areas where scavengers buy recyclables and sell them to the small junk shops. Then there are big junk shops that buy recyclables from small junk shops or scavengers and then sell them to the recycling industry.[20]

ronmental Impacts of the Existing Solid Waste Management System of Northern Lahore," *Chinese Journal of Urban and Environmental Studies* 7, no. 3 (September 2019): 1950013–2, accessed March 10, 2022, http://ezprox.bard.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=ecn&AN=1844359&site=ehost-live.

19. Fatima, Chaudhry, and Batool, "Environmental Impacts of the Existing Solid Waste Management System of Northern Lahore," 1950013–8.

20. Fatima, Chaudhry, and Batool, 1950013–19.

Another Asian city in a neighboring country which is similar in size and the utilization of the informal waste sector is Ahmedabad. In Ahmedabad, India the waste sector utilizes the informal sector in a much more diverse way besides the collection of waste. 300 families in this city work as waste collectors, rag pickers, as well as metalsmiths in the dumpsite in Ahmedabad, Pirana dumpsite. The informal waste sector finds economically valuable waste around the city and dumpsite locations to support their lives and families. In Ahmedabad these 300 families make around 150 or 200 Rs a day. The informal waste sector is a bit more formalized in Ahmedabad as they work in different parts of the waste system which Kabul can implement especially when it comes to the food waste system.[21] The authors in both articles look into the issue of the waste management in both developing countries India and Pakistan through an environmental lens. However, the article *Environmental Impacts of the Existing Solid Waste Management System of Northern Lahore* is focused on one city in Pakistan and the article *Pathways to Sustainable Waste Management in Indian Smart Cities* focuses on six cities which this literature review includes only one as most of the cities mentioned were not comparable to Kabul city such as New Delhi.

The informal waste sector also plays a big role in Kabul's waste management system. In Kabul city there are informal recyclers that are involved with the waste management system. People from the informal sector collect materials that are recyclable and transport them to recycling companies or landfills through the private sector. Recycle materials, the informal recyclers collect, are paper, metal cans, leather, plastic bottles, bones and food waste. Kabul

21. V. R. Sankar Cheela et al., "Pathways to Sustainable Waste Management in Indian Smart Cities," *Journal of Urban Management* 10, no. 4 (December 2021): 425, accessed March 8, 2022, http://ezprox.bard.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=ecn&AN=1938295&site=ehost-live.

has recycling companies for paper, plastic bottles, soft and hard plastic bags, and metal cans. "The average informal recycler in Kabul makes 2.60 dollar USD per day if collecting recyclables and food waste and not working at the transfer station. Informal recyclers working at the transfer station make 3.98 dollar per day."[22]

Most of the information about the informal recyclers in Kabul and the recycling in Kabul city comes from a survey conducted by Strong Hubs for Afghan Hope and Resilience (SHAHAR). The survey is the main focus on*Solid Waste Management in Kabul* chapter in the book *Circular Economy: Global Perspective* by Hamidullah Nikzad. This specific chapter in the book mentioned above approaches the issue of waste management through the method of surveying and gathering new information while other articles focused on India and Pakistan approach the issue through the method of researching. At the same time other papers look at the issue of waste management through an environmental lens while this book is looking at it through an economical lens and is proposing circular economy. The author mentions that informal activities that are taking place in Kabul by individuals and different NGOs and organizations to fulfill their own personal and specific goals is resulting in a circular economy such as the informal recyclers and waste pickers.

The informal waste sector in Kabul plays a role in food waste collection as well. According to the *Solid Waste Management in Kabul* case study by Nikzad, the estimated amount of waste generated in Kabul is 6500 cubic meters per day while only 450 cubic meters per day is being collected. A staggering 95 percent of the waste generated is being sent to landfills without any primary treatment, indicating a severe lack of waste management infrastructure. Addi-

22. Hamidullah Nikzad, "Solid Waste Management in Kabul," in *Circular Economy: Global Perspective* (Singapore : Springer Singapore : Springer, 2020), 45.

tionally, food and other biodegradable waste make up the largest percentage, accounting for 54.2 percent of the total waste generated.[23] At the same time, 66 percent of Samanabad's waste generation was organic waste; however, composting has been explored in Lahore waste management system. 10 percent of the organic waste is being composted by the government[24] while in Kabul there are no governmental compost facilities or programs. However, there are individuals who use food waste to feed their livestock, scavengers who use it to feed themselves or the informal recyclers collect food waste for the farmers in the outskirts of Kabul. "Food waste collectors make around 1.32 dollar per day."[25]

There is also one composting facility in Kabul called Xir Biomass Organic Fertilizer Production Company that converts biodegradable material into compost.[26] Xir Biomas was founded in 2020 by Mohammad Daud who is a professor at Kabul University. The details of whether the company still functions under the rule of the Taliban is unknown. However, most of the food waste collection through this private company involves people from the informal waste sector. In a way the involvement of the informal waste sector in waste management is inevitable because 80 to 90 percent of economic activities in Afghanistan include people in the informal sector[27] which is basically the entire city of Kabul. Private waste management, composting and recycling companies also use the informal sector as a resource and send them door to door to people's houses to collect food waste that can be composted and bottles and other materials that

23. Amiri, Tsutsumi, and Nakamatsu, "A Case Study of Fukuoka Landfill Method and Environmental Impact Assessment of Solid Waste Management in Kabul City," 47.

24. Fatima, Chaudhry, and Batool, "Environmental Impacts of the Existing Solid Waste Management System of Northern Lahore," 1950013–8.

25. Nikzad, "Solid Waste Management in Kabul," 45.

26. Mohammad Daud, *Xir Biomass Organic Fertilizer Production Company Business License*, 2022, https://rb.gy/la7gtd.

27. Schütte, "The Informal (in)security in urban Afghanistan," 469.

can be recycled. The articles on Samanabad and Ahmedabad and the article by Nikzad on Kabul view the informal sector as a part of the waste management sector while the article *A Case Study of Fukuoka Landfill Method and Environmental Impact Assessment of Solid Waste Management in Kabul City* by Abdul Wahid Amiri, talk about how the informal sector is contributing to the expansion of landfilling as the informal settlements are increasing. There are two sides to this story. However, perceiving the informal waste sector as a resource and formalizing them would help solve the waste issue in developing cities such as Kabul and create economic opportunities for people in the city.

3.2.2 Formalizing the Informal Sector to Mitigate the Waste Issue

The city of Cairo in Egypt and Iloilo in the Philippines are two developing cities that have formalized or have attempted to formalize the informal sector in order to integrate them with the solid waste management systems. However, Ragui Assad in the article *Formalizing the Informal? The Transformation of Cairo's Refuse Collection System* and Johannes G. Paul in the *Integration of the informal sector into municipal solid waste management in the Philippines – What does it need?* take different approaches to the formalization of the informal sector. Assad is an economist focused on labor economics and inequality writing about the formalization of the informal sector in the waste system in Cairo and Johannes Paul, a geologist, and environmental engineer focused on waste management and climate mitigation talk about the formalization of the informal sector. These two different research backgrounds create the difference in how they approach the topic of informality. Assad talks about the tension between the informal sector workers in the waste system and the municipality when the authorities attempted to replace the traditional system with a more

modern waste system. However, Paul talks about how the formalization of the informal sector in the city of Iloilo in the Philippines helped the waste pickers make a livelihood while also mitigating climate change. Furthermore, it is evident from the dates these articles were published that the formalization of the informal sector in Cairo in the 1980s set a precedent for Iloilo City to formalize the informal sector in the waste system in 2009.

Many studies have shown that the Informal Waste Sector (IWS) plays a larger role in the waste system than the formal waste management services. Iloilo City generates 300 tons of waste every day which 220 tons/day of that gets collected through the private sector.[28] This is 73 percent of the total waste being generated in Iloilo.[29]The way the waste collection works in Iloilo is that at the source the waste is segregated into biodegradable waste and non-hazardous industrial waste. Households bring their waste to the collection points in their own communities which are called Material Recovery Facilities (MRF). Each day is attributed to the collection of a specific kind of waste. Through the municipality, the private subcontractor collects the waste from the MRF and the collection points and transports it to the dumping sites. The dumpsite in Iloilo is located 5 kilometers away from the center of the city at Barangay Calahunan. Once the waste is transferred around 300 waste pickers which are all included in the informal sector continue in recovering materials that contain value as well as can be sold. These people rely on these informal jobs for the survival of their families and livelihood.[30]

28. Johannes G. Paul et al., "Integration of the informal sector into municipal solid waste management in the Philippines – What does it need?," *Waste Management*, Special Thematic Issue: Waste Management in Developing Countries, 32, no. 11 (November 1, 2012): 1–2, accessed April 6, 2022, https://www.sciencedirect.com/science/article/pii/S0956053X12002358.

29. Paul et al., 1–2.

30. Paul et al., 1–2.

To solve the issue of waste management the municipality integrated the informal sector into the solid waste management system by formalizing it. The way it happened was that in the year 2009 the municipality created USWAG Calahunan Livelihood Association Inc. (UCLA). The goal was to formalize the informal sector and provide them with programs that could strengthen their skills in the waste system as well as improve the different waste management programs such as composting, waste disposal, recovery, and sorting. As of November of 2012, the UCLA has 240 members who are working with the municipality to sort and recover materials that have been wasted. By being a part of this association they can explore other options as well as a source for their livelihoods such as "recovery of Alternative Fuels for commercial (cement industry) and household use, production of compost and making of handicrafts out of used packages."[31] Aside from these programs supporting the informal sector by formalizing it, improves waste system, reduces water contamination, air pollution and health risks. It also mitigates climate change by reducing GHG emissions and the production of leachate that contributes to climate change greatly.[32]

In Cairo, Egypt, however, it was not an easy task to formalize the informal since before the 1980s Cairo's waste system was managed by the informal sector and there was little to no involvement from the municipality. During the 1980s Cairo's municipality decided to replace this informal system with a more modern waste management system that was subjected to the government and municipalities regulations. In the process, they faced the Zabbaleen and Wahiya who were the two informal groups that have provided waste management services to the communities. Zabbaleen in Arabic means garbage men

31. Paul et al., "Integration of the informal sector into municipal solid waste management in the Philippines – What does it need?," 1.
32. Paul et al., 2.

the singular form is Zabal, and Wahiya means the people of Oasis who are immigrants to Cairo, the singular form is Wahi who would charge a small fee to households for the collection of their waste. After many negotiations, resistance from the Zabbaleen and the Wahiya, mediation from the Environmental Quality International (EQI) an Egyptian firm, and compromises the decision was not satisfactory to the municipality. However, it kept the social norms, practices, and rights that the informal waste sector, Zabbaleen and Wahiya, had acclaimed throughout the decades of work. The Cairo Cleansing and Beautification Authority (CCBA) granted the Zabbaleen and the Wahyia license to continue working as waste collectors. Providing them with this license the Zabbaleen and Wahyia became formalized.[33] A distinction that Assad makes in his article is the difference between scavengers and refuse workers as he says, "refuse workers who treat waste as waste by being involved in its collection, haulage, and disposal and scavengers who treat waste as ore, that is, as a source from which valuable material can be extracted." What was special about Cairo's informal waste system was that the Zabbaleen fit both categories. They were refuse workers and scavengers.

The informal sector and settlements play a role in contributing to climate change by producing waste due to lack of infrastructure as well as playing a role in solving the problem of the waste management system by being waste collectors. This paper explored the questions of how can the issue of climate change and the informal sector work together in solving the problem for both. A solution that has been incorporated in some cities mentioned above surrounds formalizing the informal sector involved with the solid waste management system. By formalizing the informal sector either through the

33. Ragui Assaad, "Formalizing the Informal? The Transformation of Cairo's Refuse Collection System," *Journal of Planning Education and Research* 16, no. 2 (1996): 115–26.

government or the private sector the informal sector makes their livelihoods and the waste management system gets to tackle the issue of waste generation and treatment through these resourceful and skilled people. However, at the same time to think that formalizing the informal sector is the solution to solve the waste management problem is naive since the informal sector is already involved with the waste system by recovering valuable materials and picking waste. The junk shops in Lahore are a great example of how the informal sector has been incorporated into the waste management system and how they are contributing to solving the problem of climate change at a local level.

To conclude this chapter, it seems from these papers that the formal sector and most of the private sectors have not been able to solve the problem of waste management in developing cities such as Kabul. This is due to the lack of proper infrastructure, decades of war, limited resources, as well as negligence on the part of the government. However, the situation could improve or potentially be solved by incorporating the informal sector as many of the cities above have done. The problem of waste management and the informal sector could potentially get solved if a community-based structure is created. The role the government and the private sectors play in solving this problem would still be crucial but they can not solve it on their own. The government of Afghanistan is not strong enough to support the solid waste management initiatives but it has the power to formalize the informal sector and help with technical solutions. This way the informal sector could adopt climate-friendly practices as well as help the solid waste management system and by that mitigating climate change. At the same time, the informal waste sector would be legitimized and would be able to make a livelihood for themselves.

In an attempt to answer the question of *Can waste management work*

in developing cities without incorporating the informal sector? These articles make it clear that waste management in developing cities is not possible without the incorporation of the informal sector. At the same time, it would be naive of the government and the private sector to ignore such a great resource. The informal sector by recovering valuable materials and things that have been wasted has developed skills and expertise that will help the government and the private sectors in developing cities to solve the issue of waste without investing so much money in technological approaches.

In order to explore the issue of waste in Kabul, specifically, food waste, data on food locations and garbage locations were gathered. These data points were analyzed and mapped in Geographical information software (GIS) to better understand the problem and propose solutions. The next chapter will provide more information on methods of data collection through GIS,food and garbage categories and funding utilized for the project.

Chapter 4

Data Collection and Methods

4.1 Geographical Information System Software

This chapter focuses on how research and remote data collection were conducted on the food and waste system in urban Kabul. The data collection was conducted through Field Maps, which is an online application in Geographical Information System (GIS) software, more specifically ArcGIS online. As there was no data or information regarding the food and waste system in the city of Kabul, the first step was to collect that data to analyze and map it in GIS. Other avenues for data collection were explored, such as My Maps through Google Maps. However, the data from Google was not sufficient because it did not fully include the data needed to conduct the project, such as specific food and waste categories. The next step was to collect the data needed for this project to be successful through the Field Maps app in ArcGIS. This was difficult because I cannot return to Afghanistan due to political instability. However, I was able to connect with local people and hire them to collect data for me. Funding was secured through Bard's Environmental and Urban

Studies department and the Open Society Engaged Research Grant to be able to pay people collecting data for this project in such a high-risk environment. Through Field Maps, 5000 data points were observed.

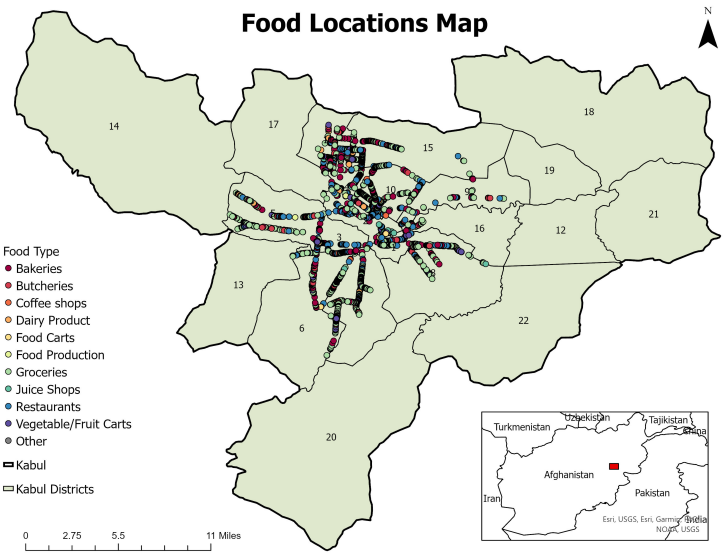

Figure 4.1: Food location data points in Kabul City.

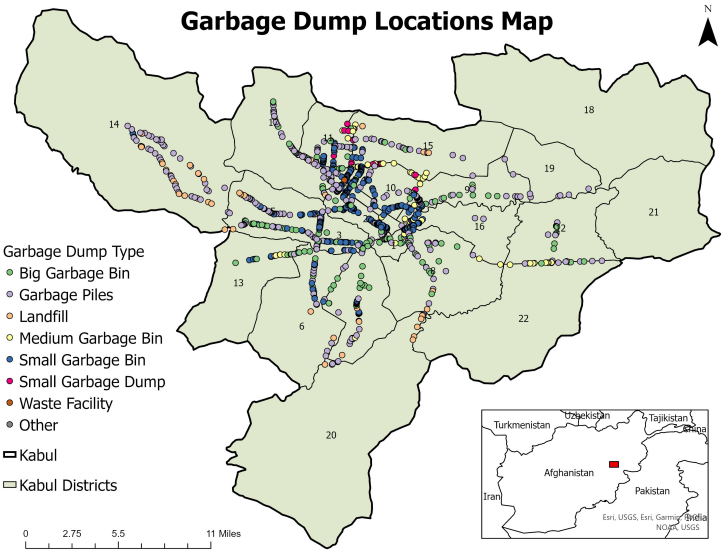

Figure 4.2: Garbage location data points in Kabul City.

4.2 Methods

This research and remote data collection were conducted using different features of GIS such as ArcGIS Online, ArcGIS Pro, and Field Maps in ArcGIS online. Although shapefiles of Kabul city were available in GIS, they were not accurate enough to conduct research through Field Maps. A shapefile is a basic format for storing information about the location and features of geographic objects, which can include points, lines, or areas and can also store additional information in a table.[1] For this project, a boundary map of Kabul City and its 22 districts were created to guide the survey work of collaborators. Using ArcGIS online, a layer was created to store all the points, which was then added to the boundary map of Kabul before being published on GIS Field Maps app. Initially, the idea was to map out everything related to food and waste in the 22 districts of Kabul, but it became clear that it was too large of a project area/survey area. Therefore, the surveyed area was narrowed down to food and waste type categories. The food type category was divided into 13 types:

1. Restaurants
2. Groceries
3. Bakeries
4. Butcheries
5. Coffee shops
6. Tea shops

1. "What is a shapefile?—ArcMap — Documentation," accessed April 18, 2023, https://desktop.arcgis.com/en/arcmap/latest/manage-data/shapefiles/what-is-a-shapefile.htm.

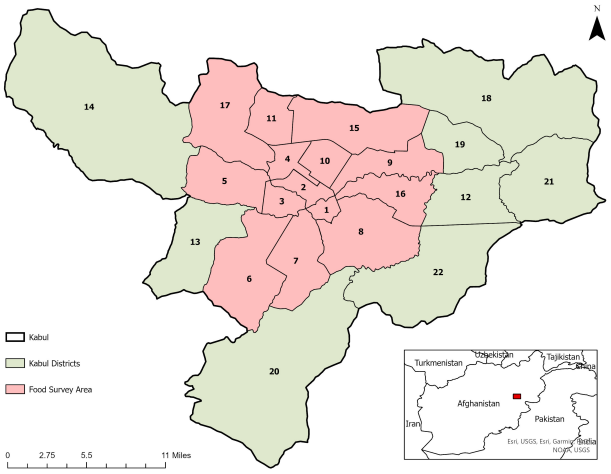

Figure 4.3: The red shows the surveyed area for food locations in Kabul City.

7. Dairy Product

8. Food Carts

9. Vegetable/fruit Carts

10. Farms/food gardens

11. Food production

12. Juice shops

13. Others

The significance of these categories lies in their relevance to people's day-to-day relationship with food. For instance, bakeries are important because bread or Afghan Naan is an essential part of the Afghan diet. Similarly, tea shops are important in Afghanistan as tea is the preferred drink over coffee among the Afghan people, although coffee shops have become more popular with the younger generation in recent years.[2] The informal sector also plays a significant

2. David Zucchino and Fatima Faizi, "In Kabul's Liberating Cafes, 'Women Make the Culture Here, Not Men'," *The New York Times*, May 25, 2019, accessed April 18, 2023,

role in the food supply options, with a variety of food and vegetable carts found throughout the city, including soup carts and carts selling cucumbers and tomatoes. The categorization process for garbage dump locations followed a similar approach. For the waste context of Kabul, the following categories were created. First, garbage was divided into eight types based on its composition:

1. Small Garbage Bin
2. Garbage Piles
3. Big Garbage Bin
4. Medium Garbage Bin
5. Landfill
6. Small Garbage Dump
7. Waste Facility
8. others

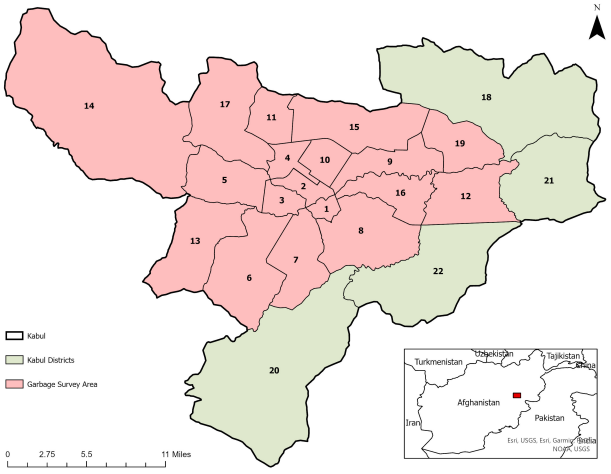

Figure 4.4: The garbage locations surveyed area in Kabul City.

https://www.nytimes.com/2019/05/25/world/asia/afghanistan-kabul-women-cafes.html.

The survey of all 22 districts was not realistic due to the lack of time and safety problems under the Taliban's regime. Therefore, the food location survey area was narrowed down to 14 districts, and the garbage dump location survey area was narrowed down to 18 districts. These districts were chosen because they are central districts with a high prediction of data availability. During the food location points surveying, districts 12, 13, 14, 18, 19, 20, 21, and 22 were avoided, and during the garbage dump location points surveying, districts 18, 20, 21, and some parts of 22 were avoided. It is worth mentioning that most of the data was collected from the main streets of the designated districts in Kabul City. Going to each district in Kabul and collecting data would require a lot more funding and time. Also, the main streets are where the most traffic and economic activities take place. Below are sample pictures of food and waste locations in Kabul city.

The next chapter focuses on the spatial analysis of food and waste systems in urban Kabul. It will provide more details on the different analyses done on the data observed, such as Local Moran's I Cluster Outlier analysis, Gi* Hot Spot analysis, Bivariate Relationship analysis, creation of heat maps, and their respective results.

Figure 4.5: Shenwari restaruant in Kabul.

Figure 4.6: A bakery in Kabul.

Figure 4.7: A juice shop in Kabul.

Figure 4.8: An ice cream shop in Kabul.

Figure 4.9: A grocery store in Kabul.

Figure 4.10: Malang super chicken soup cart in Kabul.

Figure 4.11: Logar dairy shop in Kabul.

Figure 4.12: A coffee shop in Kabul.

Figure 4.13: "Haidari" Brothers cake and cookie shop in Kabul.

Figure 4.14: A butchery in Kabul.

Figure 4.15: A blue banana fruit cart in Kabul.

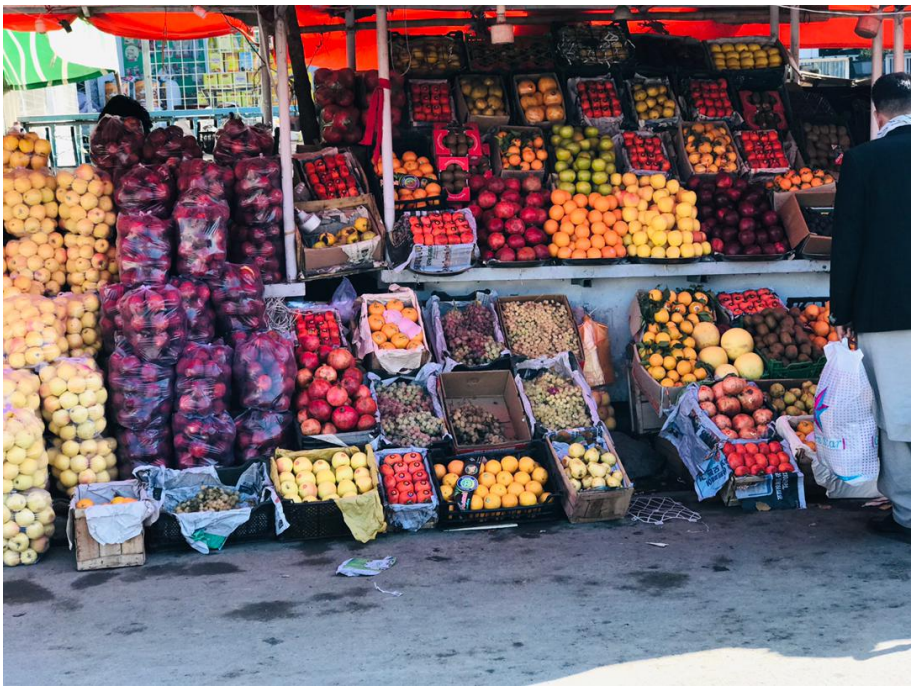

Figure 4.16: A vegetable and fruit informal stationary cart in Kabul.

Figure 4.17: A pomegranate cart in Kabul.

Figure 4.18: A tomato cart in Kabul.

Figure 4.19: A small garbage bin in Kabul.

Figure 4.20: A medium garbage bin in Kabul.

Figure 4.21: A big garbage bin in Kabul.

Figure 4.22: A garbage pile in Kabul.

Figure 4.23: A landfill in Kabul.

Figure 4.24: The Directorate of Sanitation in Kabul.

Figure 4.25: A waste facility in Kabul.

Chapter 5

Spatial Analysis of Food and Waste Systems in Urban Kabul

This chapter focuses on the different types of data analysis conducted on food and waste data points. The first section discusses heat maps of various food and garbage locations. The last three analyses include *Anselin Local Moran's I Cluster and Outlier Analysis, Gi* Hot Spot Analysis, and Local Bivariate Relationship Analysis.* These analyses were conducted using the tessellation tool, which generated a grid of regularly spaced hexagons in the surveyed food area of Kabul City. The different analyses helped identify potential locations where compost systems can be implemented based on available financial and infrastructural resources.

5.1 Heat Maps

These maps display the distribution of food and garbage locations throughout Kabul City as heat maps. The intensity of the color represents the concen-

tration of point features, with the hottest areas indicating the highest density. While heat maps provide an insightful view of data distribution, their reliability may be limited as they may not always be precise in showing point density. Therefore, other extensive analyses were performed. The first map specifically examines the density of food locations in the central regions of Kabul. Notably, the 1st district, which comprises numerous shopping centers, warehouses, and large markets around the old city, exhibited the highest concentration of food locations. The 2nd and 4th districts, known as Shar-i-naw and located around the new city, characterized by upscale restaurants, coffee shops, and large sweet bakeries, also showed a significant concentration of food locations. By analyzing the heat maps and comparing the density of food and garbage locations, it would be reasonable to suggest implementing compost systems in the 1st district around the old city, as well as the 2nd an 4th districts around the new city, as these areas have the most densely populated food and garbage locations.[1]

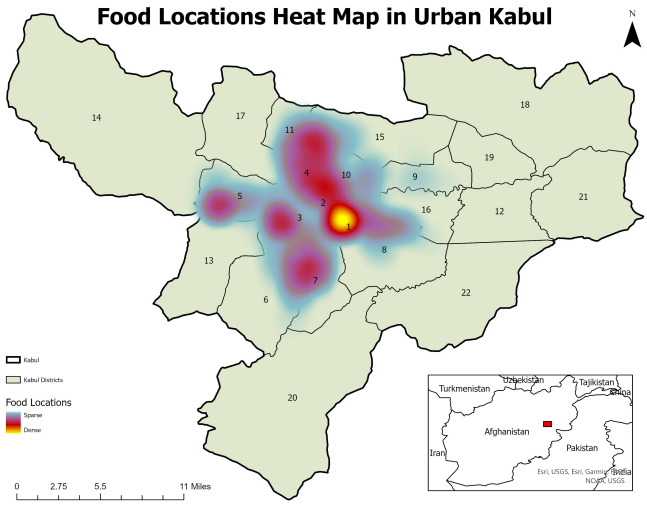

Figure 5.1: This map is a heat map of food locations in Kabul City.

1. "Create and use a heat map—ArcGIS Insights — Documentation," accessed April 18, 2023, https://doc.arcgis.com/en/insights/latest/create/heat-maps.htm.

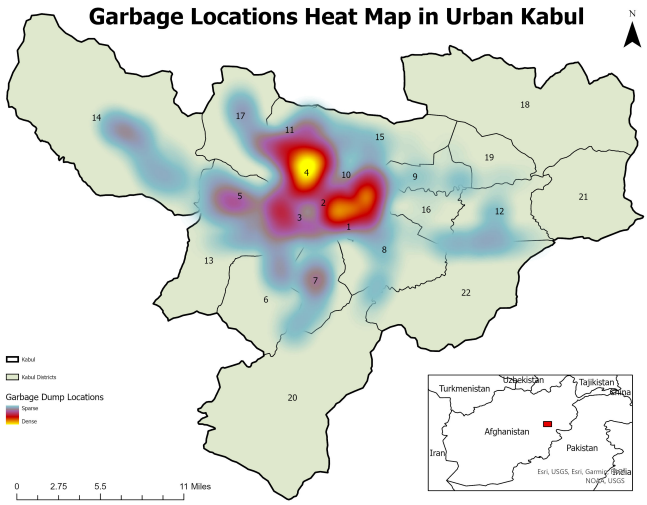

Figure 5.2: This map is a heat map of garbage locations in Kabul City.

5.2 Local Moran's I Cluster Outliers Analysis

The first type of analysis is *Anselin Local Moran's I Cluster and Outlier Analysis*, which helps identify spatial clusters with high or low values based on input feature class and input field. The *Anselin Local Moran's I* statistic is a way to identify patterns in data located in different places. For example, one can use this statistic to find places where food locations are higher or lower than expected based on the surrounding areas.[2] The tool utilizes the input feature class and input field to identify spatial clusters, ranging from high-high clusters to low-low clusters. The maps below were created based on this analysis.

2. "Cluster and Outlier Analysis (Anselin Local Moran's I) (Spatial Statistics)—ArcGIS Pro — Documentation," accessed April 18, 2023, https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-statistics/cluster-and-outlier-analysis-anselin-local-moran-s.htm.

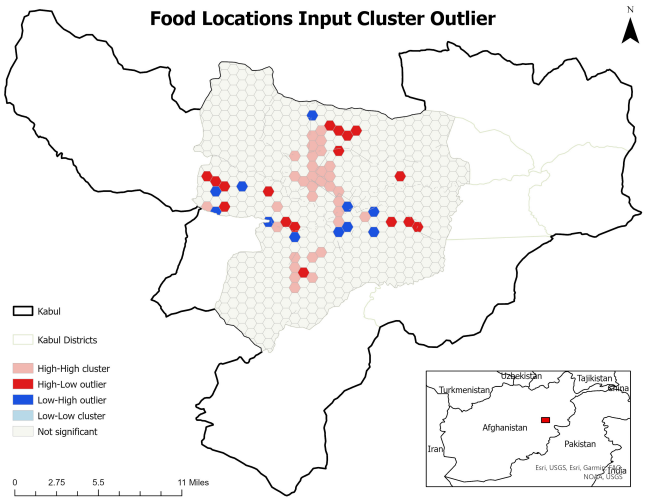

Figure 5.3: The map illustrates an input feature class of joint food and garbage locations, with the food locations input field. Pink clusters indicate high-high values of food locations, showing high concentrations not only in those areas but also in the surrounding regions.

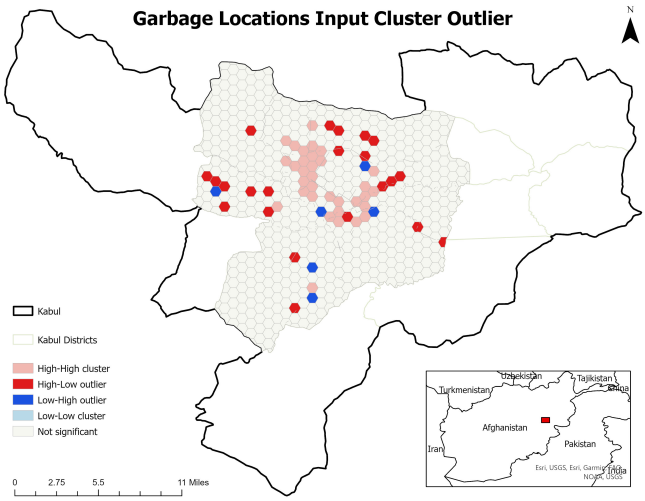

Figure 5.4: This map displays a joint feature class of food and garbage locations, with the input field of garbage locations. Pink clusters show high concentrations of garbage locations in those areas and the surrounding regions.

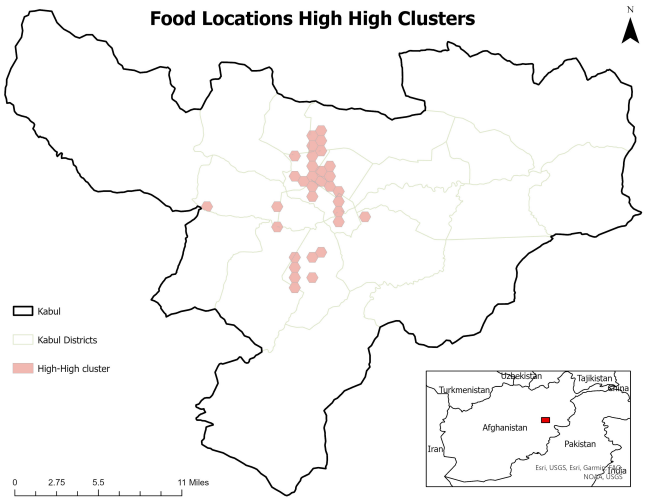

Figure 5.5: This figure displays the isolated high-high clusters of food locations from the rest of the clusters. It shows only the clusters where there are high concentrations of food locations, as well as high concentrations of food locations in the surrounding areas.

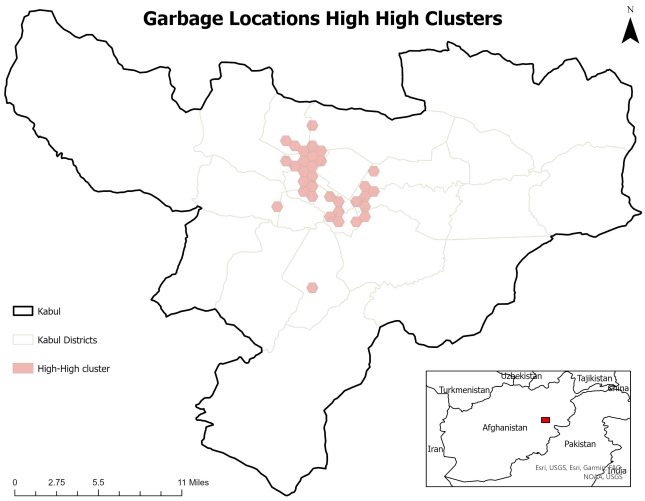

Figure 5.6: This map shows the high-high clusters of the garbage locations input, meaning that the clusters represent areas where there are high concentrations of garbage locations, and the surrounding areas also have high concentrations of garbage locations.

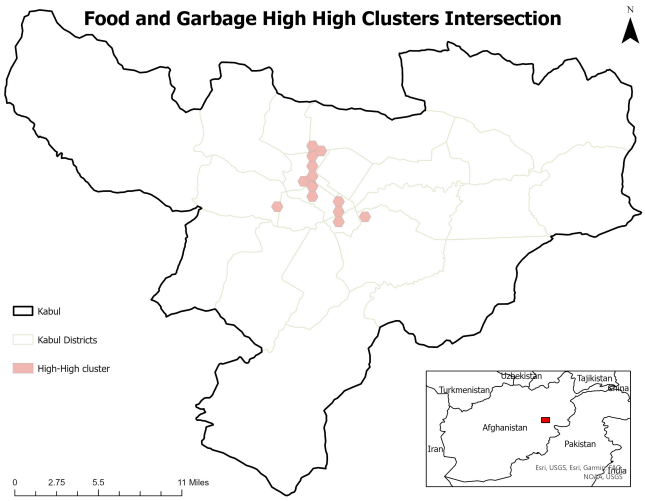

Figure 5.7: This map shows the intersection between the high-high clusters of food locations and garbage locations. The pink clusters indicate areas where both food and garbage locations are highly concentrated, as well as the surrounding areas. Installing compost sites in these locations will help mitigate the problem of food waste the most, since they are where the majority of food and garbage locations are located.

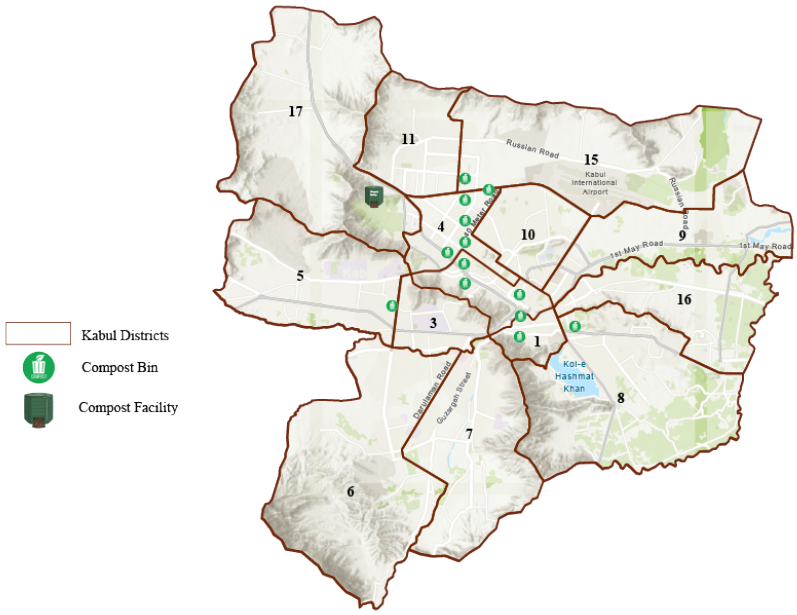

Figure 5.8: The figure depicts potential compost locations based on high-high clusters of food and garbage locations, identified using *Anselin Local Moran's I Cluster and Outlier Analysis*. The compost facility is situated in the 17th district, and the figure was created using the GIS Illustrator feature.

5.3 Gi* Hot Spot Analysis

The second analysis was conducted using the *Gi* Hot Spot Analysis* tool. The *Getis-Ord Gi** statistic is a method for identifying places where data significantly differ from the average. For example, if one has data about garbage dump locations in various neighborhoods, this statistic can be used to find neighborhoods where the number of garbage dumps is higher or lower than the average. This tool examines one feature in the context of the surrounding features. To be classified as a hot spot, a feature must have a high value and be surrounded by other features with high values.[3]

3. "Hot Spot Analysis (Getis-Ord Gi*) (Spatial Statistics)—ArcGIS Pro — Documentation," accessed April 18, 2023, https://pro.arcgis.com/en/pro-app/latest/tool-reference/

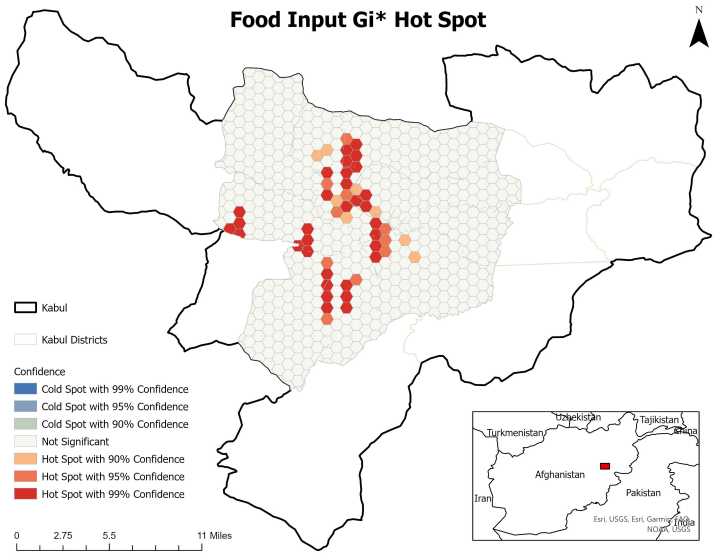

Figure 5.9: This map, created with the *Gi* Hot Spot Analysis* tool, shows red hot spots indicating high values for food locations and their surrounding areas, with a 99 percent confidence level.

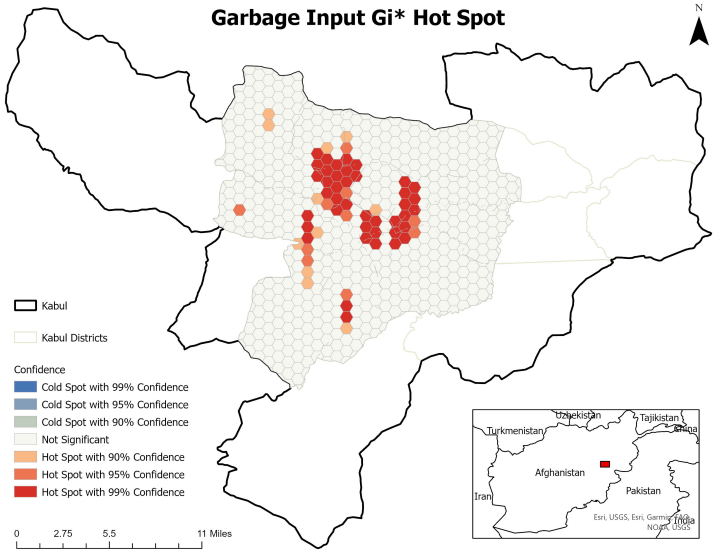

Figure 5.10: The map displays garbage hot spots as red hexagons, representing locations with a 99 percent confidence level, where surrounding features also has high values.

spatial-statistics/hot-spot-analysis.htm.

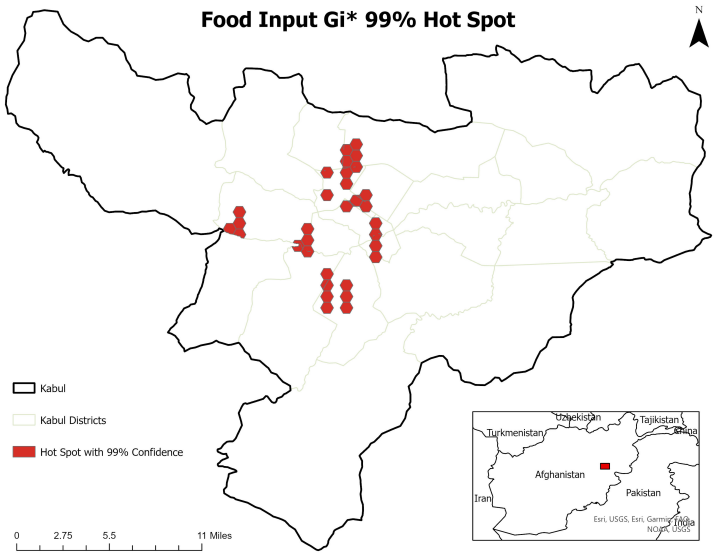

Figure 5.11: This map only displays the isolated hot spots for food locations with 99 percent confidence.

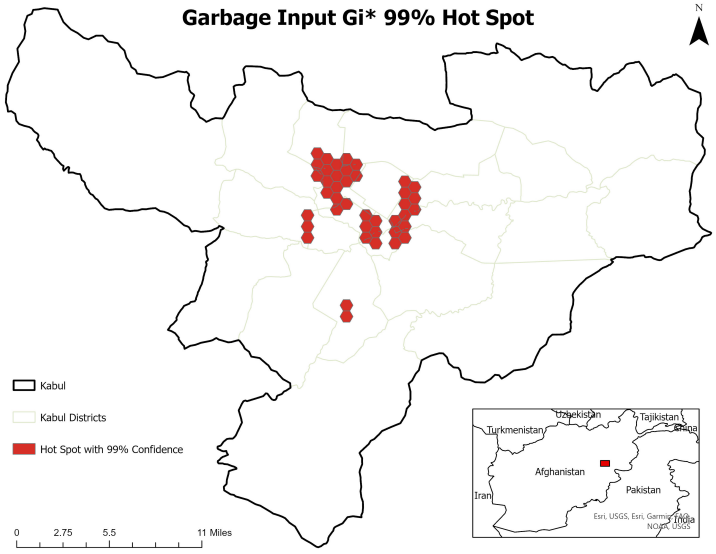

Figure 5.12: This map only displays isolated hot spots for garbage dump locations with 99 percent confidence.

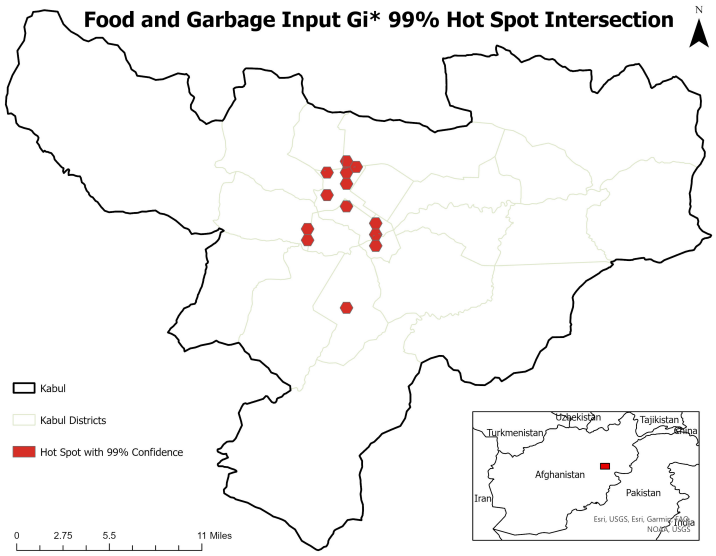

Figure 5.13: This map was created using the intersect tool, which intersected two feature classes: the food locations hot spots with 99 percent confidence and the garbage locations hot spots with 99 percent confidence. The red hexagons show the locations where both food and garbage values are the highest, as well as the features surrounding them.

Figure 5.14: This potential compost locations map was designed in Illustrator based on the final *Gi* Hot Spot* map. The map displays only the intersection between food and garbage hot spots with 99 percent confidence. Implementing the compost project in Kabul City based on this map will require minimal resources, as the compost bins will be located in the central districts and closer to the compost facility. Although it may not be comprehensive, it still provides an opportunity for composting to become a part of the waste management culture in Kabul.

5.4 Local Bivariate Relationship Analysis

The third and final analysis was conducted using the *Local Bivariate Relationship Analysis*, which allows for the comparison of two variables, such as food and garbage locations. This statistical tool helps to quantify the relationship between two variables shown on the same map, determining whether the values of one variable are influenced by the values of another variable and

whether those relationships vary over geographic space. In this instance, the tool was used to investigate whether there is a relationship between food locations and garbage dump locations in different districts of Kabul City. By examining the map, one can determine if there are areas where garbage locations are higher or lower than expected based on the explanatory variable of food locations, and this relationship can also be analyzed vice versa.[4]

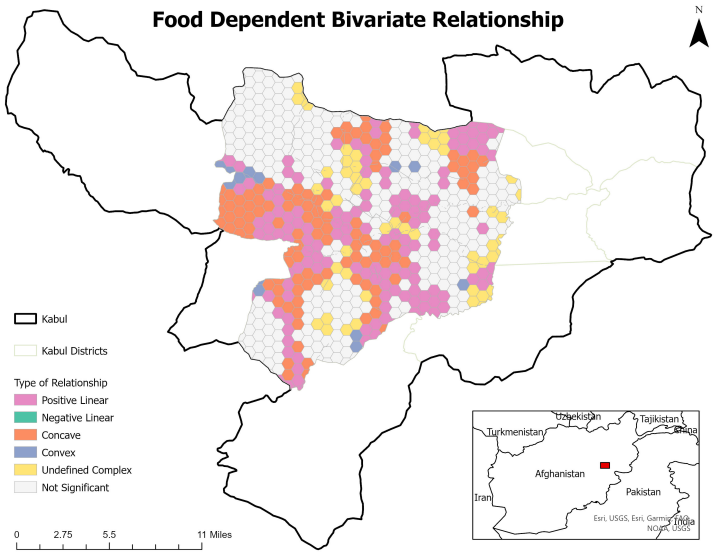

Figure 5.15: This map shows food locations as the dependent variables and garbage locations as the explanatory variables. The pink hexagons represent positive linear relationships, meaning that as food locations increase, garbage locations also increase.

4. "How Local Bivariate Relationships works—ArcGIS Pro — Documentation," accessed April 18, 2023, https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-statistics/learnmore-localbivariaterelationships.htm.

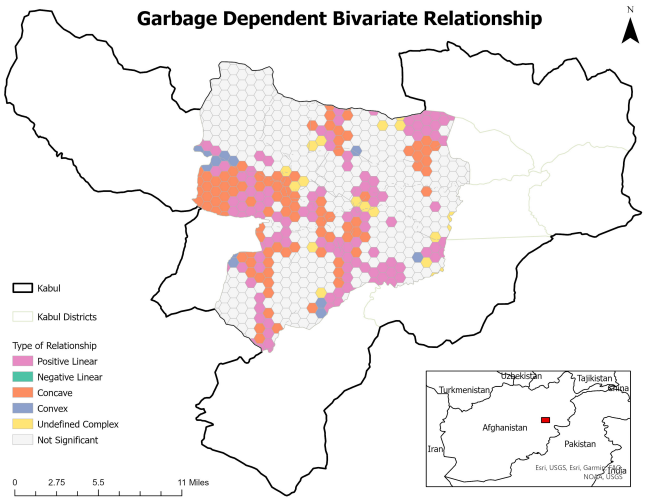

Figure 5.16: This map shows garbage locations as the dependent variable and food locations as the explanatory variable. Again, the pink hexagons represent a positive linear relationship between food and garbage locations, indicating that as garbage locations increase, food locations also increase linearly.

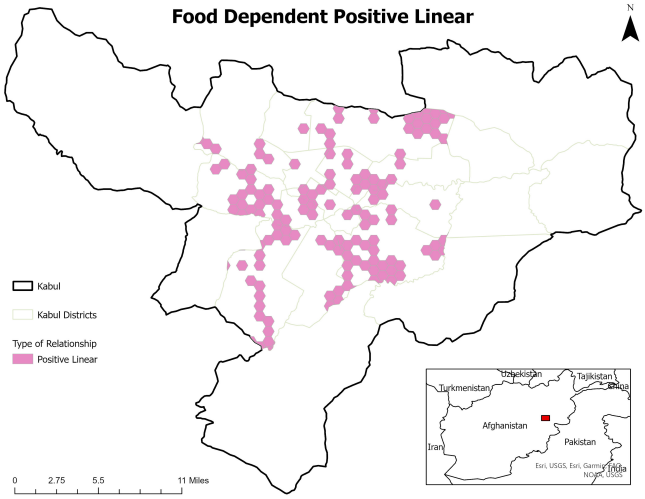

Figure 5.17: This map only shows the positive linear relationship between food locations as the dependent variable and garbage locations as the explanatory variable.

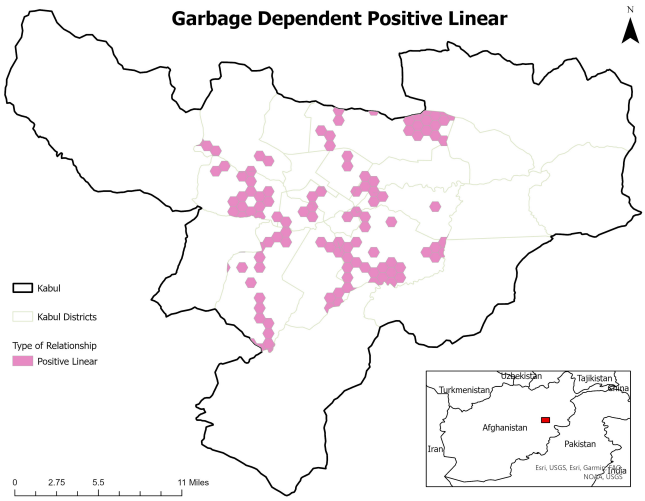

Figure 5.18: This map only shows the positive linear relationship between garbage locations as the dependent variable and food locations as the explanatory variable.

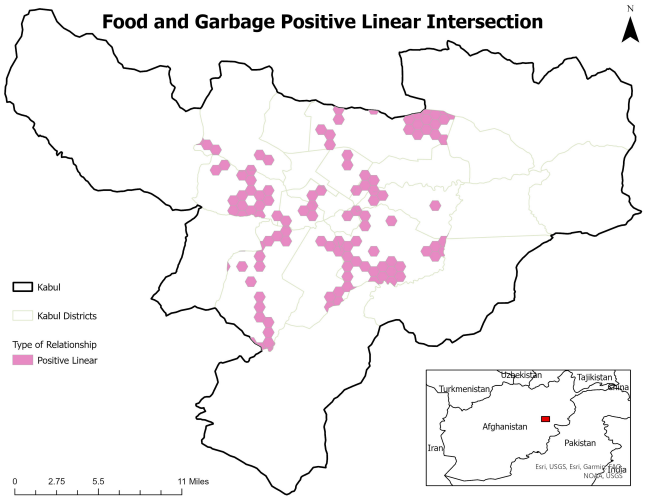

Figure 5.19: This map shows the intersection between the positive linear features of food and garbage locations. The pink hexagons represent locations where both food and garbage locations have a positive linear relationship, meaning that as food locations increase, garbage locations also increase, and as garbage locations increase, food locations also increase.

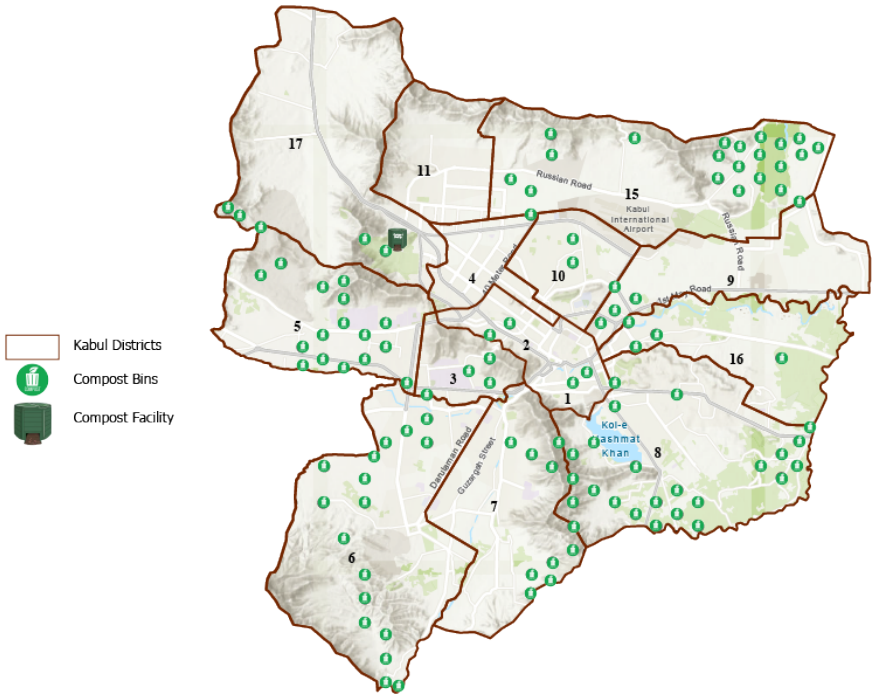

Figure 5.20: This compost location map, created in Illustrator using the final *Local Bivariate Relationship* map, depicts the intersection between the positive linear relationship of food and garbage locations. Implementing this comprehensive compost project in Kabul City will require more financial resources due to the increased number of compost bin locations in most districts.

5.5 Summary of the Data Analysis

The different analyses helped identify where compost bins should be located, as well as the compost facility/facilities. Exploring the intersection between the food and garbage locations helped identify sites where compost bins can be placed to prevent and reduce the 54.2 percent of food waste entering Kabul's garbage dumps/landfills. The final maps, Figures 5.8, 5.14, and 5.20 from each analysis, are helpful. The green points on each map indicate potential locations for compost bins. Depending on the financial and infras-

tructural resources available, the compost bins can be placed in any of the locations indicated by the green points in the given maps. The *The Bivariate Relationship* final map, Figure 5.20, indicates a need for more compost bins; while it may require more resources, it is a more comprehensive and localized system. The compost facility in Figures 5.8, 5.14, and 5.20 is located in district 17, not in the center of the city. It is situated next to a farm, shown in the imagery picture below, as the farm will be able to use the compost. Additionally, the location is close to the directorate of sanitation, which is situated in district 4. The reason for not placing the facility next to the directorate of sanitation is the lack of space, as indicated by the imagery maps.

Figure 5.21: An imagery photo of the potential compost facility site in the 17th district of Kabul City, next to a farm.

The next chapter will explore how the informal sector can be a part of this potential compost systems upon implementation and maintenance. The chapter will provide a policy proposal that fits Kabul's social, economical, and environmental context.

Chapter 6

Policy Proposal

This chapter is a policy proposal of an optimized solid waste management system in Kabul City. It provides a summary of the drivers, the issue of solid waste management in Kabul City, proposing a policy and describing the intended policy outcomes.

6.1 Summary of Drivers

The policy proposed in this brief focuses on tackling food waste in the city of Kabul which is a big part of the solid waste management system in the city. Kabul is a developing city with a lot of political, economical, social, and environmental problems. However, solid waste management has been a prominent one since Kabul municipality is dependent on landfilling and open burning methods when it comes to garbage treatment. This is because these methods are simple and versatile. Kabul also has little to no social and physical infrastructure to support waste prevention, source separation, no incineration system, no municipal or community compost systems, and no municipal recy-

cling factories. There are no legal enforcement nor incentivized policies that could help create a better solid waste system for the city.[1]

Moreover, Kabul is the fifth fastest-growing city in the world, which demands the expansion of dumpsites, landfills, and open burning facilities.[2] With 70 percent of its area being informal settlements, these practices have a significant impact on the landfills.[3]Furthermore, the reliance on unmanaged landfills poses enormous health risks, as it causes air pollution and threatens water resources. For instance, the Kampani dumpsite is upstream and located dangerously close to the city's drinking water well. In addition, the untreated garbage produces CH4 and CO2, which are the two largest GHG and contribute significantly to global warming and climate change.[4] Therefore, this policy brief aims to propose ways of improving the solid waste management system in Kabul, specifically by involving important food waste treatment methods and the informal sector.

In the city of Kabul, 54.2 percent of waste is food and biodegradable materials.[5] Food waste contributes greatly to the generation of GHG emissions. If food waste was a country it would be the third-largest GHG emitter after China and the United States. It accounts for 6 percent of total GHG emissions.[6] About 6-8 percent of all human-caused greenhouse gas emissions could be reduced if we all stopped wasting food.[7] 26 percent of total GHG emissions

1. Amiri, Tsutsumi, and Nakamatsu, "A Case Study of Fukuoka Landfill Method and Environmental Impact Assessment of Solid Waste Management in Kabul City," 4.

2. Rasmussen, "Kabul – the fifth fastest growing city in the world – is bursting at the seams."

3. Schütte, "The Informal (in)security in urban Afghanistan," 470.

4. Amiri, Tsutsumi, and Nakamatsu, "A Case Study of Fukuoka Landfill Method and Environmental Impact Assessment of Solid Waste Management in Kabul City."

5. Amiri, Tsutsumi, and Nakamatsu, 47.

6. "Food production is responsible for one-quarter of the world's greenhouse gas emissions."

7. "Food production is responsible for one-quarter of the world's greenhouse gas emissions."

come from food production.[8] To shift these statistics, composting is one of the most important and promising solutions where food waste can undergo either an aerobic or anaerobic decomposition process and be composted which is a natural process of recycling biodegradable materials such as food waste. The 54.2 percent of food waste and biodegradable materials in Kabul's solid waste management system could be prevented from ending up in landfills and open burning through composting.

6.2 Policy Proposal

The overarching policy aims to formalize the informal sector by implementing a decentralized and centralized compost system within communities. The key actors in these policy proposals are the 22 districts, as seen in Figure 3.1, private sectors, the informal sector within the waste system, and Kabul's municipality. Supporting policy measures include the creation of a cooperative by community members to support the compost system and the workers by selling the compost. Figure 6.1 below explains how the policy would function. As there are 22 districts in Kabul City, a decentralized compost will be implemented in all districts, making it a community-based initiative that can be resilient against political crises. Leaders from these districts will create a cooperative and become shareholders. The "passing lawyers," who have been appointed and elected to leadership positions in Kabul's districts, and who are trusted by the community, will function as members of this cooperative. They have the best interests of the people in mind, and are well positioned to contribute to the success of the initiative. Another advantage of having these leaders is that they work with the government but do not get paid by

8. "Food production is responsible for one-quarter of the world's greenhouse gas emissions."

the government. They get paid by the people in the community and can be a bridge between the communities and the government.

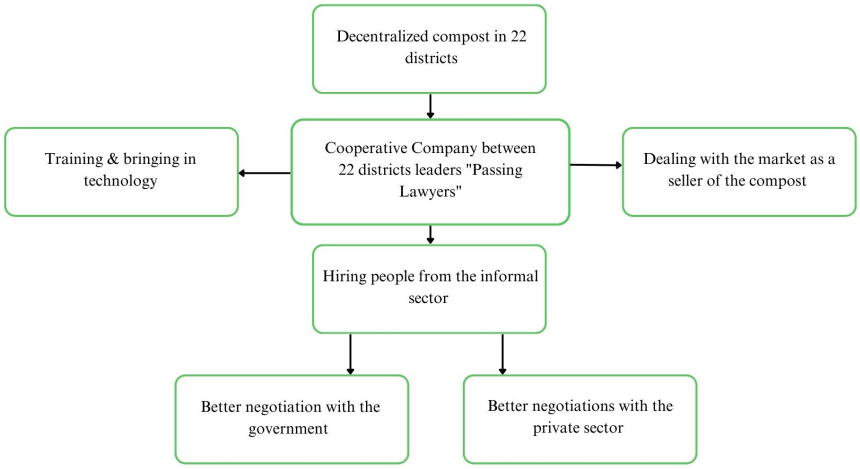

Figure 6.1: A flow chart of the policy proposal.

As there are districts with better socioeconomic backgrounds, such as the new city area district 2nd and 4th, they will provide subsidies to financially support the cooperative. However, the districts with lower economic backgrounds will provide subsidies in the form of skilled labor, such as district 1st.

The cooperative plays an essential role in the scaled economy as they can train workers, bring in and share technologies and infrastructure that can further improve the waste system in the city of Kabul. Additionally, they are dealing with the market as compost sellers. The most important part is that they can hire people from the informal sector, thus formalizing the informal sector. The benefit of formalizing the informal sector is that they can better negotiate with the government and the private sector because they are part of a cooperative now. It is important for it to be a community-based initiative because if big private sectors were involved, they could potentially pay low

wages to the workers and treat them badly. However, this policy recognizes the informal sector as part of the formalized community, giving workers in this sector a voice in the initiative.

The policy would implement a system that is centralized in some ways and decentralized in others. The compost system is decentralized across the 22 districts of Kabul based on the potential compost sites map that would be implemented. This policy proposal aligns with the Bivariate Relationship result map Figure 5.20 as the density of compost bins around the city helps decentralize composting and create more learning opportunities for residents. However, they are all centralized through the cooperative, and the "passing lawyers" act as shareholders in this cooperative. Each community needs to retain some control over its operations because this way, the workers are treated well, and there are more educational opportunities for community members, as well as a sense of responsibility since it is incorporated into their day-to-day lives. If there was only one compost system somewhere far away from the 22 districts, people would not have been involved and would not realize how important source separation of waste is and how waste can be turned into renewable energy. By establishing a centralized cooperative, the workers and employees can have stronger bargaining power during negotiations with the government, private sectors, and the market where they sell their compost. This would ensure that their voices are better heard, and they can collectively negotiate better prices for their product.

6.3 Intended Policy Outcomes

There are numerous intended policy outcomes that are economic, social, and environmental in nature. The economic outcomes include the cooperative

generating revenue, reducing poverty by hiring people from the informal sector and paying them better, and investing in the city's waste infrastructure to create decentralized compost systems in the 22 districts. This will also open up the possibilities of bringing in technologies such as a compost digester that can create renewable energy from compost since it is combustible. Besides being used as a fertilizer or soil amendment, compost can be used to provide nourishment for soil improvement and crop productivity.[9] This will contribute to the economy by increasing the amount of produce available for domestic use or export. The benefits of compost can be maximized by using it to trap methane and using it as gas for vehicles, generating heat, and producing electricity since it is easily combustible.[10]

This policy will also enhance the labor sector's wages and productivity. There are also great social benefits tied to this policy as it will improve public health by preventing 54.2 percent of waste from going to landfills and open burning through composting. This will in turn decrease air pollution and improve public health. The policy will provide training and bring in technologies to improve the skills of the labor sector, while also protecting workers in the informal sector through its community-based approach. It will also help farmers and fertilizer companies since Kabul is an urban space and there is not a lot of use for the compost so the surplus will be sold in the market or to farmers by the cooperative. Also, some of the compost could be used for parks, trees, and plants around the city.

9. Thi Thien Kim Ho et al., "Compost to improve sustainable soil cultivation and crop productivity," *Case Studies in Chemical and Environmental Engineering* 6 (December 1, 2022): 6, accessed May 15, 2022, https://www.sciencedirect.com/science/article/pii/S2666016422000330.

10. Wen Yi Chia et al., "Sustainable utilization of biowaste compost for renewable energy and soil amendments," *Environmental Pollution* 267 (December 1, 2020): 267, accessed May 15, 2022, https://www.sciencedirect.com/science/article/pii/S0269749120363508.

Finally, there are incredibly important environmental outcomes. It contributes to Sustainable Development Goals starting with SDG 11. Sustainable Cities and Communities (SDG), SDG 1. No Poverty, and SDG 13. Climate Action. It also contributes to a clean waste system since it will prevent the largest portion of waste from going to landfills as biodegradable materials such as food. It further cleans water and sanitation by preventing water contamination and it will contribute to renewable energy in the future since compost is combustible and can produce electricity and heat as well as gas. Also, this policy is in alignment not only with the sustainable solid waste management system in the city of Kabul but also Sustainable Development Goals (SDG) and Intergovernmental Panel on Climate Change (IPCC) 2021 Report and the global action plan in regards to mitigating climate change.

6.4 Future Considerations

In conclusion, this project aims to address the major problem of food waste in Kabul by exploring the intersection between food locations and garbage locations to implement potential compost systems. The analyses and results presented here provide a foundation for diverting food waste to compost at a community and municipality level. The next step worth exploring is determining the most efficient transportation routes between compost bin collection locations and the compost facility based on the four potential compost bins and facility maps. Additionally, it will be valuable to analyze social aspects such as the concentration of waste in areas with different household incomes, the role of residents in mitigating food waste, and the cost of implementation. Ultimately, this is a project that I hope to seek funding for and implement in the near future.

Bibliography

Amiri, Abdul Wahid, June-ichiro Giorgos Tsutsumi, and Ryo Nakamatsu. "A Case Study of Fukuoka Landfill Method and Environmental Impact Assessment of Solid Waste Management in Kabul City." 4, no. 4 (2016): 6.

Assaad, Ragui. "Formalizing the Informal? The Transformation of Cairo's Refuse Collection System." *Journal of Planning Education and Research* 16, no. 2 (1996): 115–126.

Cheela, V. R. Sankar, Ved Prakash Ranjan, Sudha Goel, Michele John, and Brajesh Dubey. "Pathways to Sustainable Waste Management in Indian Smart Cities." *Journal of Urban Management* 10, no. 4 (December 2021): 419–429. Accessed March 8, 2022. http://ezprox.bard.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=ecn&AN=1938295&site=ehost-live.

Chia, Wen Yi, Kit Wayne Chew, Cheng Foh Le, Su Shiung Lam, Chelsea Siew Chyi Chee, Mae See Luan Ooi, and Pau Loke Show. "Sustainable utilization of biowaste compost for renewable energy and soil amendments." *Environmental Pollution* 267 (December 1, 2020): 115662. Accessed May 15, 2022. https://www.sciencedirect.com/science/article/pii/S0269749120363508.

"Cluster and Outlier Analysis (Anselin Local Moran's I) (Spatial Statistics)—ArcGIS Pro — Documentation." Accessed April 18, 2023. https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-statistics/cluster-and-outlier-analysis-anselin-local-moran-s.htm.

"Create and use a heat map—ArcGIS Insights — Documentation." Accessed April 18, 2023. https://doc.arcgis.com/en/insights/latest/create/heat-maps.htm.

Daud, Mohammad. *Xir Biomass Organic Fertilizer Production Company Business License*, 2022. https://rb.gy/la7gtd.

Fatima, Syeda Amber, Mohammad Nawaz Chaudhry, and Syeda Adila Batool. "Environmental Impacts of the Existing Solid Waste Management System of Northern Lahore." *Chinese Journal of Urban and Environmental Studies* 7, no. 3 (September 2019): 1–21. Accessed March 10, 2022. http://ezprox.bard.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=ecn&AN=1844359&site=ehost-live.

"Food production is responsible for one-quarter of the world's greenhouse gas emissions." Our World in Data. Accessed May 15, 2022. https://ourworldindata.org/food-ghg-emissions.

Fox, Sean, Tom Goodfellow, and Jo Beall. *Cities and development*. Second edition. Routledge perspectives on development. London ; Routledge, Taylor & Francis Group, 2016.

Ho, Thi Thien Kim, Van Tung Tra, Thanh Hai Le, Ngoc-Kim-Qui Nguyen, Cong-Sac Tran, Phuong-Thao Nguyen, Thi-Dieu-Hien Vo, Van-Nam Thai, and Xuan-Thanh Bui. "Compost to improve sustainable soil cultivation and crop productivity." *Case Studies in Chemical and Environmental Engineering* 6 (December 1, 2022): 100211. Accessed May 15, 2022. https://www.sciencedirect.com/science/article/pii/S2666016422000330.

"Hot Spot Analysis (Getis-Ord Gi*) (Spatial Statistics)—ArcGIS Pro — Documentation." Accessed April 18, 2023. https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-statistics/hot-spot-analysis.htm.

"How Local Bivariate Relationships works—ArcGIS Pro — Documentation." Accessed April 18, 2023. https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-statistics/learnmore-localbivariaterelationships.htm.

Khoshbeen, Ahmad Rashid, Mohanakrishnan Logan, and Chettiyappan Visvanathan. "Integrated solid-waste management for Kabul city, Afghanistan." Company: Springer Distributor: Springer Institution: Springer Label: Springer Number: 1 Publisher: Springer Japan, *Journal of Material Cycles and Waste Management* 22, no. 1 (January 1, 2020): 240–253. Accessed April 9, 2022. https://link.springer.com/article/10.1007/s10163-019-00936-z.

Kumar, Chandra Bhushan. "Climate Change and Asian Cities : So Near Yet So Far." *Urban Studies* 50, no. 7 (May 1, 2013): 1456–1468.

Masson-Delmotte, Valérie, Panmao Zhai, and Anna Pirani. *Climate change 2021: the physical science basis : summary for policymakers : working group I contribution to the sixth Assessment report of the Intergovernmental Panel on Climate Change*. OCLC: 1353287322. Geneva, Switzerland: IPCC, 2021.

Nikzad, Hamidullah. "Solid Waste Management in Kabul." In *Circular Economy: Global Perspective*, 43–65. Singapore : Springer Singapore : Springer, 2020.

Paul, Johannes G., Joan Arce-Jaque, Neil Ravena, and Salome P. Villamor. "Integration of the informal sector into municipal solid waste management in the Philippines – What does it need?" *Waste Management*, Special Thematic Issue: Waste Management in Developing Countries, 32, no. 11 (November 1, 2012): 2018–2028. Accessed April 6, 2022. https://www.sciencedirect.com/science/article/pii/S0956053X12002358.

Rasmussen, Sune Engel. "Kabul – the fifth fastest growing city in the world – is bursting at the seams." *The Guardian*, December 11, 2014. Accessed March 17, 2022. https://www.theguardian.com/cities/2014/dec/11/kabul-afghanistan-fifth-fastest-growing-city-world-rapid-urbanisation.

Schütte, Stefan. "The Informal (in)security in urban Afghanistan." *Iranian studies*, 2009.

"Solid Waste Management." World Bank. Accessed March 17, 2022. https://www.worldbank.org/en/topic/urbandevelopment/brief/solid-waste-management.

"What is a shapefile?—ArcMap — Documentation." Accessed April 18, 2023. https://desktop.arcgis.com/en/arcmap/latest/manage-data/shapefiles/what-is-a-shapefile.htm.

Zucchino, David, and Fatima Faizi. "In Kabul's Liberating Cafes, 'Women Make the Culture Here, Not Men'." *The New York Times*, May 25, 2019. Accessed April 18, 2023. https://www.nytimes.com/2019/05/25/world/asia/afghanistan-kabul-women-cafes.html.