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URBAN DEVELOPMENT AND WASTE MANAGEMENT PLANNING IN KABUL NEW CITY, AFGHANISTAN: A CASE STUDY

Wafaurahman Wafa[1], Amir Hamzah Sharaai[2]*, Sifatullah Mukhtar[3], Kawoon Sahak[4], Fazal Rahman Afghan[5]

[1,4,5]*Faculty of Environment,*
KABUL UNIVERSITY JAMAL-MINA AFGHANISTAN
[2] *Faculty of Forestry and Environment,*
UNIVERSITI PUTRA MALAYSIA
[3] *Infrastructure Planning and Designing* Division,
DEHSABZ-BARIKAB KABUL AFGHANISTAN

Abstract

The municipal solid waste collection system and services of existing Kabul City are not acceptable socially, economically, and environmentally. This study was carried out in 2020–2021 for the Phase-1 area of Kabul New City (KNC). The study aims to analyze different MSWCSS for the KNC area and choose the best option during the planning stage. The average incremental cost for different collection systems was determined, and the results show that the total annualized cost (AN) of the proposed waste collection system (PWCS) is 855.3699 AFN/tonne, while the total operation and maintenance cost (OP) is 577.1235 AFN/tonne. The AN and OP of the stand-alone underground waste collection system (SAUWCS), tailored collection point system, traditional (prevailed) system, and alley waste collection system (AWCS) are 911.3032 AFN/tonne and 499.9017AFN/tonne, 1,681.762 AFN/tonne and 1,267.28 AFN/tonne, 308.9254 AFN/tonne and 186.3363 AFN/tonne, and 716.7706 AFN/tonne and 410.5375 AFN/tonne, respectively. The social and environmental analysis for the PWCS, SAUWCS, existing system, and AWCS obtained scores of 19, 29, -6, 17, and -5, respectively. From the cost-benefit analysis, it has been proposed that for the PWCS of low-rise residential areas, three wheelie bins of different colors will be provided to each housing unit. The total costs per tonne of solid waste for the PWCS, SAUWCS, TCPS, and traditional system are 2,832.1952, 3,638.137205, 3,888.6272, 751.45984, and 1,975.8152, respectively. For the PWCS of residential areas, chute waste collection systems are planned for high-rise apartment buildings and SAUWCSs are planned in commercial areas.

Keywords: Municipal Solid Waste Collection, Collection System and Services, Cost-Benefit Analysis, Sustainable Development

[2] Corresponding author-mail: amirsharaai@upm.edu.my

INTRODUCTION

Municipal solid waste management (MSWM) is a major concern around the world. The increasing production of municipal solid waste (MSW) is one of the most severe problems, particularly in urban areas of developing nations. The rapid growth of population, urbanization, and economic development has exacerbated its severity, making it problematic (Chuah et al., 2023). Due to the way cities in developing countries are built, how quickly they are growing, and the lack of resources to give them the infrastructure and urban services they need, trash is not picked up well enough and is often dumped in the streets, empty lots, and open dumps (Andrianisa et al., 2016).

Municipal solid waste is an environmental concern in cities; hence, local governments and private enterprises must consider safeguarding human health, the environment, and natural assets (Li et al., 2022; Mukhtar et al., 2016). Solid waste collection is an important part of the solid waste management (SWM) process, accounting for up to two-thirds of the whole budget. The major costs of MSWM systems are devoted to the collection, and its optimization leads to a considerable reduction in marginal, financial, and environmental costs (Erfani et al., 2018). The rapid growth of global population expansion and the corresponding increase in the output of municipal solid garbage have given rise to a significant concern (Labib et al., 2021). Collection expenses, on the other hand, account for 80–90% and 50–80% of MSWM budgets in low- and middle-income countries, respectively. The overall amount spent on solid waste collection, transportation, and disposal is between 60% and 80% (Sulemana et al., 2018).

However, in high-income countries, waste collection costs less than 10% of the total SWM budget, compared to 80–90% in low-income countries. Moreover, waste is still picked up more often and more efficiently in high-income countries than in low-income countries. In developing countries, around 20–50% of their available budget is for SWM. Nevertheless, 30–60% of all urban solid garbage is not collected, and less than 50% of the population is served (Srivastava et al., 2015).

According to Forouhar & Hristovski (2012), in Afghanistan, SWM is one of the least studied environmental issues in many poor nations. Afghanistan, being a low-income developing country, is similarly confronted with SWM problems. Internal wars have largely damaged the urban environment in Afghanistan. According to Khoshbeen et al. (2020), in 2018, a city of 5 million people produced 3,050 tonnes of waste with per capita generation of about 0.61 kg per day. The aim of Kabul New City (KNC) is to achieve sustainable development in the planning stage, where aerial view maps make it quite easy to analyze different MSWCSS for selecting the best option for Phase-1 and the whole KNC area.

LITERATURE REVIEW

Ullah et al. (2022) concluded that the initial step in planning an effective MSW collection system is to identify and understand the existing challenges. Recent studies highlight common obstacles faced by developing countries, such as limited financial resources, inadequate waste collection infrastructure, informal waste disposal practices, and the lack of public awareness and participation.

Additionally, the specific context of KNC presents unique challenges related to post-conflict reconstruction, rapid urbanization, and informal settlements. To overcome these challenges, researchers emphasize the need for comprehensive waste management strategies that incorporate waste reduction, reuse, recycling, and proper disposal (Mohd Kusin et al., 2019).

Efficient planning and design of MSW collection systems play a vital role in achieving effective waste management. Recent research emphasizes the importance of considering several factors including population density, waste generation rates, distance to disposal facilities, and socioeconomic characteristics of the target area (Khoshbeen et al., 2020). Advanced technologies, including geographic information systems (GIS), optimization models, and route planning algorithms, are being employed to optimize collection routes and reduce operational costs.

Engaging stakeholders and promoting community participation are essential components of successful waste management initiatives. Recent studies emphasize the need for building partnerships among government agencies, waste management companies, non-governmental organizations (NGOs), and local communities (Mushkani & Ono, 2022). By involving the public in waste management planning, decision-making processes can be more inclusive, resulting in greater acceptance and adherence to waste management practices.

Case studies from other developing countries facing similar waste management challenges provide valuable insights. However, the waste management in these cities offers lessons on effective strategies, technologies, and policies that could be relevant to the planning of KNC's MSW collection system. Additionally, Khalil et al. (2019) offer useful recommendations for recycling policies that prioritize the creation of households' intentions. These proposals include the provision of recycling facilities, the encouragement of participation through market-driven recycling programs, and the promotion of recycling awareness and education. Moreover, Aminu et al. (2022) suggested the integration of non-residents into formal garbage collection necessitates the establishment of planning and policy implementation, as well as an institutional and legal framework. This is of utmost importance in order to achieve effective service delivery and satisfaction in areas that are currently not being serviced.

RESEARCH METHODOLOGY

Study Area

Afghanistan's capital city, Kabul, is in the eastern part of the country at 34°31' N and 69°12' E, 1,800 m above sea level (Wafa et al., 2020). The KNC project is located in the northwestern part of Kabul city at 69°.36'.18'' longitude, 34°.20'42'' latitude, and an elevation of 1,847 m. The project covers an area of approximately 740 km^2. There are approximately 54 villages within the KNC boundary, some of which have been destroyed or are no longer in existence, and approximately 140,000 people live within its borders (Habibi et al., 2021).

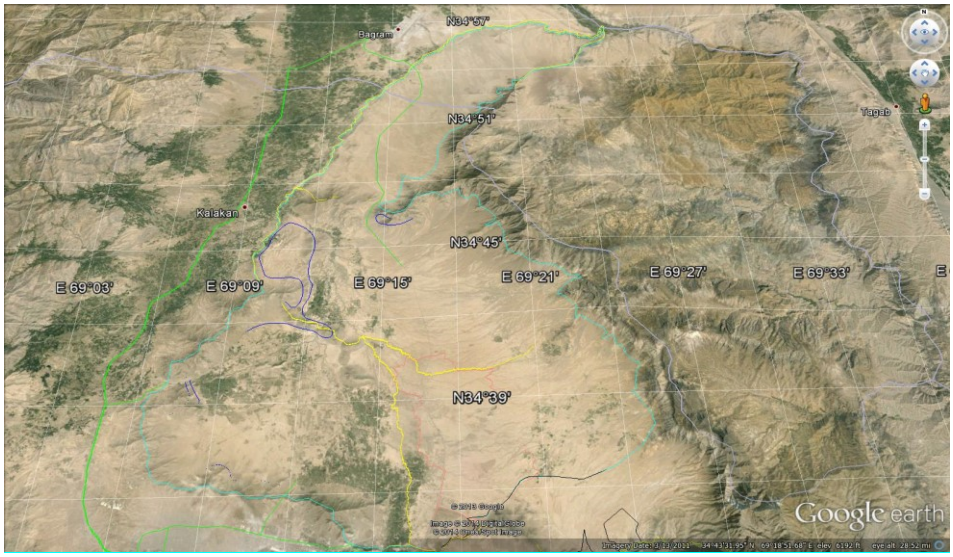

Figure 7. Figure 1: Showing the map of the whole KNC area (GIS map of Kabul New Capital)

Estimated Waste Generation Rate

Kabul's population and commercial sector are the only two major generators of MSW; the remainder comes from outside sources. the rate of solid trash production was between 0.31 kg and 0.43 kg per person per day. Meanwhile, Khoshbeen et al. (2020) stated that the amount of MSW produced in the city is predicted to increase to 3,300 tonnes per day by 2025, with a per capita production of 0.61 kg/day. A rise in garbage production per capita per day is predicted to increase by 2% on a yearly basis, which can be determined using the following formula:

$$kg/capita/day * 1 + K\%$$

For instance:

$$0.6 * 1 + \frac{2}{100} = 0.62$$

Economic and Financial Costing

Economic costing was utilized for determining the least expensive alternatives and establishing user fees for waste collection services. In order to determine the economic cost of the DCDA Phase-1 collection system, the following variables were considered:

Foreign exchange shadow factor = 1.5; opportunity cost of capita = 12%; labor cost: fringe benefits = 15%, driver pay = 12,000 AFN/month, and labor pay = 6,000 AFN/month; management and administration overhead = 10% of direct labor cost; vehicle maintenance: motorized vehicles = 20% of purchase price per year and non-motorized vehicles = 10% of purchase price per year; insurance and sundries = 5% of capital cost; economic life of vehicles = 7–15 years; economic life of container 3 and 5; and fuel cost (including tax) = 57 AFN/L.

Average Incremental Cost (AIC)

$$\frac{AIC = \sum_{t-1}^{t-T}(C_t + O_t)/(1+r)^{(t-1)}}{\sum_{t-1}^{t-T}(N_t/(1+r)^{(t-1)}}$$

Where:
t = time in years;
T = design lifetime in years (measured from the start of the project at t = 0);
C_t = construction costs incurred in year t;
O_t = incremental (from year t = 0) operation and maintenance costs incurred in year t; and
N_t = additional quantity of solid waste (from year t = 0) collected in year t.

Capital Recovery Factor (CRF)

$$\boldsymbol{CRF = \frac{r(1+r)^N}{(1+r)^{N-1}}}$$

Where:
r = interest rate; and
N = loan maturity period.

ANALYSIS AND DISCUSSION

Estimated MSW Generation of the New City

The solid waste generation in developing Asian nations ranged from 0.41 to 1.62 kg per person per day, whereas the characterized solid waste generation rate for the existing Kabul city ranged between 0. and 0.43 kg/capita/day, with approximately 70% of organic fraction including night soil with a specific weight (uncompacted waste) at the disposal site was observed (Forouhar & Hristovski, 2012).

The solid waste generation rate for Kabul City is 0.61 kg/capita/day with 52% organic fraction (Khoshbeen et al, 2020). As KNC development is in the planning stage, this characterized waste will be used for the KNC, which used 0.62 kg/capita/day starting in 2020. The annual waste in kg/capita/day of solid waste increased by 2%. As the living standard in Kabul city improves, this would increase to 0.87 kg/capita/day in 2037. Phase-1 of KNC waste generation is estimated to be 46,562 kg/day in 2020. Demographic growth is around 5%, including 3% from natural growth plus 2% from immigration (Mukhtar et al., 2016).

Table 1: Estimated waste generation

Year	Population*	Solid Waste** Generation (kg per Capita per Day)	Total Solid Waste Generation (kg per Day)	Total Solid Waste Generation (kg per Month)	Total Solid Waste Generation (kg per Year)	Biodegradable Solid Waste Generation (kg per Year) 70%	Recyclable Wholesale (kg per Year) 5%
2020	75,100	0.62	46,562	1,396,860	16,995,130	11,896,591	849,756.5
2021	112,651	0.63	71,240	2,137,215	26,002,779.73	18,201,946	1,300,139
2022	139,467	0.65	89,963	2,698,887	32,836,461.94	22,985,523	1,641,823
2023	166,283	0.66	109,406	3,282,172	39,933,090.32	27,953,163	1,996,655
2024	193,099	0.67	129,590	3,887,708	47,300,449.26	33,110,314	2,365,022
2025	219,915	0.68	150,538	4,516,153	54,946,529.32	38,462,571	2,747,326
2026	246,732	0.70	172,273	5,168,202	62,879,787.25	44,015,851	3,143,989
2027	277,366	0.71	197,536	5,926,078	72,100,616.75	50,470,432	3,605,031
2028	308,000	0.73	223,740	6,712,202	81,665,127.52	57,165,589	4,083,256
2029	338,634	0.74	250,913	7,527,401	91,583,378.47	64,108,365	4,579,169
2030	369,268	0.76	279,084	8,372,523	101,865,693.4	71,305,985	5,093,285
2031	400,000	0.77	308,357	9,250,705	1.13E+08	78,785,170	5,627,512
2032	420,000	0.79	330,250	9,907,505	120,541,309.6	84,378,917	6,027,065

Year	Population*	Solid Waste** Generation (kg per Capita per Day)	Total Solid Waste Generation (kg per Day)	Total Solid Waste Generation (kg per Month)	Total Solid Waste Generation (kg per Year)	Biodegradable Solid Waste Generation (kg per Year) 70%	Recyclable Wholesale (kg per Year) 5%
2033	441,000	0.80	353,698	10,610,938	129,099,742.6	90,369,820	6,454,987
2034	463,050	0.82	378,810	11,364,314	138,265,824.3	96,786,077	6,913,291
2035	486,203	0.83	405,706	12,171,181	148,082,697.8	103,657,888	7,404,135
2036	510,513	0.85	434,511	13,035,334	158,596,569.4	111,017,599	7,929,828
2037	**536,038**	**0.87**	**465,361**	**13,960,843**	**169,856,925.8**	**118,899,848**	**8492846**

Source: KNC Data and Author's Calculation

The population increase was assumed to be 5%*; the solid waste in kg/ capita/day was assumed to increase by 2%**.

Municipal solid waste collection in the Existing Kabul City

Garbage collection in the existing Kabul city was carried out by container collection services and door-to-door collection services Table 2.

CP Container Collection Services

In the existing Kabul city, there are approximately 4,273 collection containers, with 857 of 7 m^3 bins, 1,116 of 1 m^3 bins, and the remaining 2,300 are 0.1 m^3 bins (Khoshbeen et al., 2020). This covers an area of about 375 km^2, covering 18 cities out of a total of 22 districts. Residents bring their waste to a CP container located close to their houses. Waste spreading near the road attracts scavengers (human beings and animals). It is a deteriorating environment, which makes it unaesthetic and produces bad smells and also occupational and health problems. In Kabul city, much workforce is used to collect solid waste. According to an official of DoS, out of 3,752 DoS staff members, about 2,415 provide waste collection services, while around 1,301 are assigned to sweep the streets (Azimi et al., 2020).

Door-to-Door (D2D) System

In Kabul city, a D2D collection system has also been established in some residential areas for waste collection using compactor trucks and dump trucks. In general, there are three possibilities for collecting household garbage: municipalities collect refuse from residences using municipal employees and equipment, municipalities partner with private trash haulers to provide domestic

refuse collection services, and individual homes contract with private garbage haulers for domestic refuse collection without intervention from the municipality.

Types of Buildings and Residential and Commercial Areas in Phase-1 of KNC

The KNC area is to be divided into three phases and one agriculture economic zone (a total of four phases) until 2025, but the implementation has not been carried out to date. Phase-1 and Phase-2 development plan has been accomplished. For Phase-1 and Phase-2, the area is divided into residential areas, commercial areas, industrial parks, and greenery parks. The collection of MSW from residential and commercial areas of Phase-1 is discussed in this paper. The residential and commercial areas are:

Residential Areas in Phase-1

The residential areas in phase-1 are planned to have social housing; affordable housing; high-, medium-, and low-density housing, and villas, with the plot size of 10 × 15, 10 × 20, 12 × 25, 15 × 30, 17 × 30, and 20 × 40 m^2, respectively. The accommodation of 6–9 people with a minimum of three and a maximum of four stories is shown in Table 1.

Commercial Areas in Phase-1

For Phase-1, the commercial areas are divided into mixed residential, local commercial, district commercial, and central commercial areas, with areas of 250, 200, 150, and 110 m^2, respectively, and the area of local commercial is 60 m^2. The district commercial area covers a total of 115,000 m^2 in Phase-1, while the central commercial area is about 47,600 m^2. The local commercial area has a minimum of three and a maximum of five stories, whereas the central commercial area has a maximum of ten stories.

Proposed Collection System for Phase-1 Area

Developing countries spent 20–40% of municipal revenues on solid waste collection. Out of the total money spent on SWM, 60–80% is spent on the collection of solid waste (Bhargava et al., 2019). Improvement of collection operation by a small percentage can give significant savings in the overall cost. The collection system for the Phase-1 area is proposed as follows:

Solid Waste Collection for Residential Areas

A 2,410 m^2 area is allocated for the residential houses in the Phase-1 of KNC. Three different colored wheelie bins will be used by each house for onsite segregation and the collection of waste in each residential house. The waste from these wheelie bins will be collected door to door. It will be transported to the transfer station that has been planned in Phase-1. The KNC area will have

recycling industries. The feedstock of these recycling industries will be taken from the KNC area. Onsite segregation will be carried out by the residents. Different studies show that the segregation of these wastes by NGOs or private entities gives great benefits. Also, local people will improve the habits of source segregation. In 7 years, the privatization of solid waste collection activities has improved from 10% to 40%. For attaining sustainability in waste management, this approach by NGOs or private entities is considered to be the right measure (Kassim & Ali, 2006). A 1-year survey of 126 municipalities indicated that contracting solid waste collection services saved a significant amount of money (McDavid, 1985). Therefore, the Phase-1 area of KNC will be given either the recyclables or other waste collection by the NGOs, CBOs, etc. or it will be given to the municipality, and it will be decided later in the operation and maintenance of the area. A compactor truck will be used for the collection of this garbage.

Solid Waste Collection for Commercial Areas

However, securing the investment cost for a pneumatic waste collection system is hard for developing countries, and the maintenance procedure is also complicated. A pneumatic waste collection system provides the best environmental performance. From another point of view, pneumatic waste collection methods are better than traditional ones because they make less noise, cause less accidents, smell less, and cause less traffic jams. Nonetheless, under an existing metropolitan infrastructure, the total air emissions would increase (Vásquez et al., 2013). A special compactor truck will be used for the collection of garbage from the commercial areas.

High-Rise Apartment Buildings

Most high-rise apartment buildings with more than seven floors have a chute collection system. The same approach will be used for KNC. For the efficiency of the collection system for high-rise apartment buildings, the chute collection system will be used for the Phase-1 area. It has been planned in this stage that the chute system could be used for apartment buildings with more than seven floors. A compactor truck will be used for the collection of garbage.

Transfer Station

One transfer station has been selected for the Phase-1 area with a land size of approximately 2 hectares. The transfer station and its routing for the collection of solid waste have not been considered because the tertiary roads have not been finalized yet. For transportation, the distance taken into consideration is 149.6 km of the total Phase-1 roads (primary and secondary). In more detail, the complete solid waste collection system will be prepared with a more realistic approach after the complete routing of collection services. More detailed routing of the collection system will be carried out using GIS/CAD software.

Table 2: Showing cost of different waste collection system in AFN

	Proposed waste collection system		**Stand Alone Underground Waste Collection system**		**Tailored System Proposed by JICA study team**			**Traditional Used as a Restrain or Control system.**		**Alley Container Collection services**	
Capital	**Vehicles**	**Container**	**Vehicles**	**Container**	**Vehicles**	**Container**	**Civil work**	**Vehicles**	**Container**	**Vehicles**	**Container**
Purchase price per unit	2280000	5070	4000000	441752	2280000	19950	5000	23960	19950	1140000	28500
Total Purchase unit	44	2254	**15**	221	100	1391	464	113	1391	63	125
Estimated life (years)	15	5	15	15	15	3	20	7	3	7	3
Foreign Exchange shadow factor	1.5	1.5	1.5	1.5	1.5	1.5	0	1.5	1.5	1.5	1.5
Shadow system Purchase	150480000	17140158	90000000	146,470,253	34224754 1	41631302	2318646.729	40612200	4163 1302.02	10695235 6.6	534761 8
Total shadowed system vehicles + container	**167620158**		**236,470,253**		**386197490**			**45692522**		**112299974**	
Operation and Maintenance											
Driver	528000		180000		12008691			13560000		750543	
Unskilled Laborer	264000		90000		600434			678000		375271	
Shadowed unskilled labor shadow factor	1		1		1			1		1	
Shadowed unskilled labor cost	264000		90000		600434			678000		375271	
Total shadowed system labor cost	**792000**		**270000**		**1801303**			**2034000**		**1125814**	
Fuel in Afghani/ liter for the tripping in whole phase-1 area with tax	921063		251199		1674660			1892366		1055036	
Total	**921063**		**251199**		**1674660**			**1892366**		**1055036**	
Vehicles Maintenance	30096000	17140166	18000000	14,647,025	68449508	41631302	231865	81224413	4163130	21390471.31	534762
Total Maintenance cost	**31810016**		**32,647,025**		**72844503**			**4975374**		**21925233**	

Management and administration overheads (10 % of direct labor cost)	7920 0	251 20	180 130	203 400	1125 81
Total System management	7920 0	251 20	180 130	203 400	1125 81
Insurance and sundries (5% of capital cost)	**7524 000**	**4,50 0,00 0**	**171 123 77**	**203 061**	**5347 618**
Total system Operation and Maintenance cost	**41047079**	**37,668,224.28**	**93432843**	**9104801**	**29453701**
Waste collection					
Trip per day	2	2	2	2	2
Tons per trip	101	103 s	101	100	98
Tons per year 365 working days	73677	75351	73677	72921	71744

Source: Kabul city Municipality

CONCLUSION

The development of a comprehensive and efficient MSW collection system is crucial for the sustainable development of KNC in Afghanistan. This research focused on planning an effective MSW collection system and services in KNC by considering the problems of waste management in emerging countries. The study emphasized the importance of understanding the challenges, such as limited financial resources, inadequate infrastructure, informal waste disposal practices, and lack of public awareness and participation.

The research aimed to propose a waste collection system that addresses the specific needs of KNC and promotes sustainable development. Various approaches were employed, including estimating waste generation rates, conducting economic and financial costing, and utilizing cost-benefit analysis. These methods provided insights into waste generation levels, costs associated with waste collection, and potential benefits of different collection system options. Based on the findings, suggestions were made on how the MSW collection system in KNC should be set up. These include implementing door-to-door collection for residential areas, a stand-alone underground system for commercial areas, and a chute collection system for high-rise buildings. Factors such as population density and waste generation rates were considered in determining the appropriate system for each area. The research emphasized the importance of stakeholder engagement and community participation in waste management initiatives. Building partnerships among government agencies, waste management companies, NGOs, and local communities is essential for

inclusive decision-making and successful implementation of waste management practices.

The proposed waste collection system offers a promising approach to address waste management challenges in KNC. By optimizing collection routes, reducing costs, and promoting waste reduction and resource recovery, the system can contribute to environmental sustainability and public health in KNC. However, implementing the proposed system will require careful planning, investment, and ongoing monitoring and evaluation. Collaboration, adequate funding, and continuous education and awareness programs are necessary for the long-term success and sustainability of the MSW collection system in KNC. Overall, this research provides valuable insights and recommendations for the planning and development of an effective MSW collection system in KNC, Afghanistan. By addressing specific challenges and considering sustainable waste management practices, KNC can work toward a cleaner, healthier, and more environmentally friendly future.

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