

The Republic of the Sudan

FY2020 Ex-Post Evaluation Report of Japanese Grant Aid Project

"The Project for Improvement of Solid Waste Management in Khartoum State"

External Evaluator: Koichi Sekita, Chuo Kaihatsu Corporation

0. Summary

This project aims to improve the capacity to collect and dispose of waste in Khartoum State, the Republic of the Sudan (hereinafter referred to as Sudan), by procuring waste collection and transport equipment and final disposal facility operation equipment, and by establishing a maintenance workshop to service waste collection and transport equipment, thereby contributing to improvement of the hygienic environment in the region. This project is consistent with the development plan and development needs of Sudan at the time of the ex-ante evaluation and the ex-post evaluation, and is consistent with Japan's ODA policy at the time of the ex-ante evaluation. Therefore, the relevance of this project is high. Regarding the project costs and the results of the project period, the project costs were kept within the plan, but the project period exceeded the plan, so the efficiency is fair. As for effectiveness, the achievement rate of the waste collection amount was 71% for the result one year after the completion of the project compared with the target value. The waste collection rate was 55% and the achievement rate was 69% in comparison with the target value of 80%. In addition, it can be said that the qualitative effect of suppressing the production of bad smell, insect pests, and smoke damage is observable in the responses of staff in the final disposal site. In terms of impact, there seems to be a positive effect on the surrounding hygienic environment, but the presence of final disposal sites is considered to be a negative factor for the neighboring residents, and the improvement is difficult to see due to the dissatisfaction with the current situation. Based on the above, although the targets expected via the project implementation have been achieved to a certain extent, the effectiveness and impacts are fair as there are some problems that can be seen in the expression of some after-effects. Regarding sustainability, while vehicle maintenance technology at the Central Workshop is maintained, problems are seen in parts procurement by each Locality Cleaning Affiliate. In addition, with each year since the completion of the project, it is becoming more difficult on the financial side due to the deterioration of security and fiscal instability in Sudan. Although the financial resources necessary for the continuation of the effects of the program and for the operation and maintenance of materials and equipment are currently insufficient, the program continues with limited financial resources. From these, the sustainability is judged to be fair.

In light of the above, this project is evaluated to be partially satisfactory.

1. Project Description



Project Location



Garbage Collection Vehicles (Compactor)

1.1 Background

In Khartoum State, where the Sudanese capital Khartoum is located, nearly 5,000 tons of wastes per day are generated as urban populations increase. The Locality Cleaning Affiliates (LCA) of seven localities collect and transport waste under the direction of the Khartoum Cleaning Corporation (KCC). These seven localities have a total of 301 waste collection vehicles, but they do not meet the number required, and the collection of waste generated is only 65% (3,200 tons/day of collection). In many of the areas where waste collection is not carried out, waste is left in residential areas, etc., and bad smell, insect pests, etc., are generated, which leads to deterioration of the hygienic environment. The state of Khartoum has three final disposal sites, which receive wastes 24 hours a day and dispose of them in landfills. The operation of the disposal site is carried out by the KCC, but equipment is insufficient, and the soil covering has not been sufficiently implemented. Therefore, waste is scattered around, and ignition and field burning are carried out by some waste pickers¹, etc.

Khartoum Environmental Protection Law enacted in 2008 establishes state-level waste control. In addition, the *Solid Waste Management Master Plan in Khartoum State* was formulated in 2013. This Master Plan aims to "improve the collection rate to 90%" by 2028. This project contributes its realization.

1.2 Project Outline

The objective of this Project for Improvement of Solid Waste Management in Khartoum State is to improve the capacity to collect and dispose of waste by procuring waste collection and transport equipment and final disposal facility operation equipment, and by establishing a

¹ People who earn money by recovering and selling valuable resources such as bottles and cans informally at roads and waste disposal sites in developing countries (National Institute for Environmental Studies, Knowledge of Circulation and Waste)

maintenance workshop to service waste collection and transport equipment, thereby contributing to improvement of the hygienic environment in the region.

Grant Limit / Actual Grant Amount	1,534 million yen / 1,352 million yen
Exchange of Notes Date /Grant Agreement Date	February 2014 / February 2014
Executing Agency	Khartoum Cleaning Corporation
Project Completion	October 2016
Target Area	7 Localities in Khartoum State (Khartoum, Bahary, Jabal Aulia, Karary, Omdurman, Sharg En Nile, Um Badda)
Main Contractor(s)	Facility: Lot-2: Sato Kigyo Co., Ltd. Equipment: Lot-1: FutureBud International Co., Ltd. Lot-3: Sojitz Corporation
Main Consultant(s)	Yachiyo Engineering Co., Ltd.
Preparatory Survey	June 2013 – March 2014
Related Projects	[Technical Cooperation] Project for Strengthening Solid Waste Management in Khartoum State in the Republic of the Sudan (2014-2017)

2. Outline of the Evaluation Study

2.1 External Evaluator

Koichi Sekita, Chuo Kaihatsu Corporation

2.2 Duration of Evaluation Study

This ex-post evaluation study was conducted with the following schedule.

Duration of the Study: November, 2020 – March, 2022

Duration of the Field Study: July 24, 2021 – August 5, 2021

2.3 Constraints during the Evaluation Study

Due to the impact of the new coronavirus pandemic, field surveys were conducted only once, and subsequent information gathering was conducted through local consultants. In addition, since communication with implementing organizations became difficult due to political changes in October 2021, the evaluation was made using information from before the occurrence of the

political change, and there is a possibility that it might not reflect the latest local conditions.

3. Results of the Evaluation (Overall Rating: C²)

3.1 Relevance (Rating: ③³)

3.1.1 Consistency with the Development Plan of Sudan

The target of this project is consistent with the target (90% waste collection rate by 2028) in *the Solid Waste Management Master Plan in Khartoum State* (2013) addressed by Sudan.

Regarding waste management in Khartoum State, *the KCC Vision for Reform of the Cleaning Program (VRCP)* (2017-2030) and the annual plan for 2017 have been prepared.⁴

According to the KCC, no further revisions have been made to *the Solid Waste Management Master Plan in Khartoum State* revised in the Technical Cooperation Project.

Based on the above, there are no changes in development policies and plans throughout Khartoum State, particularly in the environmental and sanitation sectors, and it is concluded that this project is consistent with Sudan's development policies during planning and ex-post evaluation.

3.1.2 Consistency with the Development Needs of Sudan

In Khartoum State, the subject area of this project, the LCAs of the seven localities are responsible for waste collection and transport operations under the guidance of the KCC, and also under the direction of the Higher Council of Environmental and Natural Resources⁵ (HCENR).

According to HCENR, in 2017 Sudan (data from 12 of all 18 states) generated 16,811 tons/day of waste, of which 6,000 tons/day were generated in Khartoum. Among the 12 states where waste generation is known, waste generation in Khartoum is the highest, accounting for 35.7% of the total of 12 states. The estimated waste generation in Khartoum State in the Preparatory Survey (2014) was 4,890 tons/day. In 2020, waste generation in seven localities in Khartoum State obtained from the KCC was 6,706 tons/day. Comparing waste generation in Khartoum State in 2020 and 2014, waste generation increased ($6,706 \text{ tons/day} \div 4,890 \text{ tons/day} = 137\%$), and waste generation continues to increase.

Based on the above, the development needs of Sudan at the time of planning and at the time of the ex-post evaluation matched as the project attempted to solve the above-mentioned issues by improving the collection capacity of waste and the ability to dispose of waste.

² A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory

³ ③: High, ②: Fair, ①: Low

⁴ Technical Cooperation Project Completion Report

⁵ Changed from the former Ministry of Environment/Natural Resources/Urban Development (Ministry of Environment, Natural Resources and Physical Development: MENRPD) due to the reorganization of the Ministry of Land, Infrastructure and Transport

3.1.3 Consistency with Japan's ODA Policy

This project is consistent with the Japanese support for Sudan during the ex-ante evaluation and the joint declarations made at the Fifth Tokyo International Conference on African Development (TICAD V) (Summary Table of the Evaluation Survey Results at End of the Technical Cooperation Project). The Joint Declaration sets out "building a society in which everyone can benefit from growth" as a priority area, and its Action Plan ("Promotion of Comprehensive Waste Management" is a priority area in the TICAD V Yokohama Action Plan 2013-2017) mentions "Support for Reinforcement of Waste Management in Large Cities" as an item that Japan will proactively implement.

Based on the above, this project meets the priority areas for the African region and contributes to solving the issues specified in the priority areas, and it is therefore judged to have been consistent with Japan's ODA policy.

3.1.4 Appropriateness of the Project Plan and Approach

This project aims to improve the collection capacity of waste and the waste disposal capacity. The project carried out "Procurement of Equipment" such as equipment for waste collection and transport and for final disposal site operation, and "Construction of Central Workshop" for improving waste collection and transport equipment. In these efforts, the Project planned to expand the fleet and equipment to directly improve the capabilities of waste collection and disposal, to develop workshops that will serve as central facilities to improve the ability to maintain and manage such vehicles and equipment, and further to strengthen maintenance and management technologies through soft components. In addition, a technical cooperation project taking place during the same period, "The Project for Strengthening Solid Waste Management in Khartoum State of the republic of the Sudan" (hereinafter referred to as the "Technical Cooperation Project") was implemented, aiming to maximize the waste management capacity of the state of Khartoum while effectively utilizing the equipment procured in this project, and to improve the hygienic environment in the same region with synergistic effects.⁶

It is concluded that the synergistic effects with the purpose of this project can be expected from Outputs 2⁷ and 3⁸ of the technical cooperation. With regard to Indicator 2-1⁹, the Technical Cooperation Project Completion Report stated that, based on past performance, the amount of waste disposal would reach 4,610 tons/day as of August 2017, and it was expected that the target would be achieved (as of 2017) through activities under the Technical Cooperation Project, utilizing the equipment procured in this project. In addition, in Output 3, the equipment procured in this project was utilized in the disposal site, and the achievement target in 2017 was expected

⁶ Summary Table of the Evaluation Survey Results at End of the Technical Cooperation Project

⁷ Output 2: Improved waste collection and transport capacity.

⁸ Output 3: Improved operation and management of final disposal sites.

⁹ Indicator 2-1: Waste collection will increase from 3,200 tons/day to 4,601 tons/day in 2017.

to be achieved in the same way as with Output 2. The approach of this project was appropriate in that the equipment and facilities provided and maintained by the Grant Aid would continue to be utilized in the Technical Cooperation Project and its effects would spread within Khartoum State.

This project has been highly relevant to the country's development plan and development needs, as well as Japan's ODA policy. Therefore, its relevance is high.

3.2 Efficiency (Rating: ②)

3.2.1 Project Outputs

Table 1 shows a comparison of the planned and actual outputs of this project.

Table 1 Comparison of Plans and Results

Details of the plan				Quantity		
				Planning	Actual	Difference
Equipment procurement	Waste collection equipment	Compactor	Used for collecting and transporting household and market waste.	40 units	42 units	2 units increased
		Container Carrier arm type (body + container)	Mainly used for collection and transportation of market waste.	40 units	56 units	16 units increased
		Collection container		40 units	56 units	16 pieces increased
	Equipment and materials for the operation of landfills	Soil-covering compactor (Bulldozer or land-fill loader)	Used for levelling and compressing waste at disposal sites and for soil covering operations.	3 units	3 units	No change
		Excavator	Used for excavating and obtaining covering soil.	2 units	2 units	No change
		Water-supply truck	Used to transport drinking-water to offices and waste pickers.	1 unit	1 unit	No change
	Vehicle maintenance equipment for Central Workshop		Used for vehicle maintenance at the Central Workshop to be constructed in this project.	1 set	1 set	No change
	Vehicle maintenance equipment for local workshops		Used for vehicle maintenance at existing workshops.	1 set	1 set	No change
	Construction of Central Workshop			Carries out maintenance of waste collection equipment and materials for this project.	1 set	1 set
Capacity building program (soft component)			Conducts technical training related to the operation of the Central Workshop and vehicle maintenance.	1 set	1 set	No change

In this project, equipment procurement (Lot-1) was carried out in January 2014, reducing the number of procured units to 40 compactors and 40 container carriers as there was fear that the cost of the procurement quantities originally planned would be excessive. In reality, price

competition resulted in a 383-million-yen surplus, so the Ministry of Environment, Forestry and Physical Development sought to make efficient use of the residual, and requested JICA to procure 18 additional vehicles to secure 98 vehicles, the number of vehicles that had originally been planned for, for which additional procurement was carried out as Lot-3. This eventually resulted in the procurement of quantities as originally planned (98 collection vehicles and 6 units of equipment for final disposal sites). Of these, 4 compactors and 11 container carriers were deployed to collect medical-related wastes under direct control of the KCC. The additional procurement equipment, which had initially been reduced due to the limitation of the project budget, was secured using the residual money generated as a result of the bidding for this project. It is judged to be reasonable because it contributes to improving the waste collection capacity in this project.

Table 2 and Table 3 show the arrangement of donated equipment (collection vehicles and equipment for final disposal sites) heard from the KCC in the on-site survey.

Table 2 Breakdown of waste collection equipment by LCAs as answered by the KCC (at the time of ex-post evaluation)

* Figures in parentheses are at the time of Outline Design

Unit: Vehicle

	Khartoum Locality	Bahary Locality	Jabal Aulia Locality	Karary Locality	Omdurman Locality	Sharg En Nile Locality	Um Badda Locality	KCC (for medical waste)	Total	Total (Interview with each LCA at the time of the ex-post evaluation*1)
Compactor	5(11)	5(10)	7(3)	5(2)	5(5)	6(7)	5(2)	4	42	38(40)
Container Carrier arm types	6(12)	7(9)	7(3)	6(2)	6(4)	7(7)	6(3)	11	56	45(40)
Total	11(23)	12(19)	14(6)	11(4)	11(9)	13(14)	11(5)	15	98	83(80)

*1 Sums of the figures reported and confirmed by each LCA through on-site surveys and questionnaires at the time of the ex-post evaluation

Table 3 Breakdown of vehicles for final disposal site managed by the KCC (at the time of ex-post evaluation)

	Unit: Vehicle			
	Khartoum	Bahary	Omdurman	Total
Bulldozer	1	1	1	3
Excavator	0	1	1	2
Water-supply truck	1	0	0	1
Total	2	2	2	6

3.2.2 Project Inputs

3.2.2.1 Project Cost

Of the project contents planned in the Preparatory Survey, equipment procurement costs were significantly lower than the planned price, while facility construction costs were significantly higher. As a whole, there was a large surplus, and it was appropriated to procure additional equipment. Through the Outline Design and Detailed Design, the equipment procurement cost was estimated at 1,287 million yen and the facility construction cost at 176 million yen. Comparison of Detailed Design and actual operating costs is shown in Table 4 below.

Table 4 Comparison between Outline Design (O/D), Detailed Design (D/D), and actual results

	Unit: million yen			
Item	O/D	D/D (A)	Actual (B)	Difference (B-A)
Equipment procurement cost (Lot-1)	1,293	1,287	749	-538
Facility Construction Cost (Lot-2)	170	176	328	152
Cost of additional equipment procurement (Lot-3)	-	-	158	158
Consultant cost	73	73	93	20
Total operating costs	1,536	1,536	1,328	-208

Source: JICA Provided materials, Preparatory Survey Report

As shown in the table above, in the bidding for equipment procurement (Lot-1), the price was lower than the planned price, and surplus was generated. On the other hand, the construction of the Central Workshop (Lot-2) significantly exceeded the planned price in the first bidding, resulting in poor bidding¹⁰. After reviewing the planned price¹¹ and utilizing surplus funds for equipment procurement (Lot-1), the construction contractor was decided at the second bidding.

¹⁰ The reason for this was that the bidder adopted an expensive estimation proposal presented by the local contractor who had a track record of grant aid by Japan. Construction results, and the fact that the inflation rate in Sudan (2013) was 41.90% compared to the previous fiscal year (IMF: April 2014)) were also considered factors behind the soaring unit price of construction.

¹¹ In addition to examining the estimates of the unit cost of labor, unit cost of materials, unit price of leased construction machinery, unit cost of material and construction, etc., at the time of the project cost review implementation (as of October 2014), the project cost estimation was carried out by collecting estimates from local contractors who had experience of subcontracted works with Japanese construction companies in charge of Grant Aid Projects.

Subsequently, based on the results of Lot-1 and Lot-2 procurement, additional procurement reached the equipment requirements of the initial plan (Lot-3) utilizing the surplus generated. In addition, regarding vehicles provided by the project, in order to promote Japan's support, the design has been changed to attach stickers using surplus money.

The actual operating costs against the planned operating costs were 87% (1,328 million yen (actual) ÷ 1,534 million yen (plan) = 87%). For this reason, the project cost was within the plan.

3.2.2.2 Project Period

The planned project period and its results are shown in Table 5.

Table 5 Outline of project period

Item	Planning	Actual
Project period	February 2014 to August 2015 (19 months in total)	From April 2014 to October 2016 (31 months in total) *From the start of Detailed Design up to the completion date of additional procurement (Lot-3).
Detailed Design period	5.5 months (Detailed Design period to Bidding Management)	6.0 months (Detailed Design Period to Bidding Management)
Construction period	13.5 months Equipment procurement: 12.0 months Facility construction: 10.0 months	25.0 months Equipment procurement (Lot-1): October 2014 to January 2016: 16 months Construction of facilities (Lot-2): February 2015 to April 2016: 15 months Additional procurement (Lot-3): November 2015 to October 2016: 12 months

Initially, two lots were planned: Lot-1 (equipment) and Lot-2 (construction). Using the surplus, Lot-3 (additional procurement) was added to the project, resulting in a total of three lots. In Lot 2 (construction), the construction period was extended twice due to remaking the implementation system, reconstruction to ensure construction quality, and the delays in customs clearance procedures for equipment procured in Japan. However, the period from the start of the Detailed Design to the additional procurement contract Lot-3 was evaluated as being that of the entire project.

Based on the initial completion schedule (August 2016) of Lot-3 (additional procurement) with the commencement of the Detailed Design (conclusion of the consultant contract in April 2014) as the cardinal point, the planned project term for the entire project (from Lot-1 to Lot-3) is considered to be 29 months from April 2014 to August 2016. Actual results from Detailed Design inception through the date of completion of Lot-3 (October 31, 2016) are 31 months. As a result, the project period exceeded the plan (31 months (actual) ÷ 29 months (plan) = 107%).

Although the project cost was within the plan, the project period exceeded the plan. Therefore, efficiency of the project is fair.

3.3 Effectiveness and Impacts (Rating: ②)¹²

3.3.1 Effectiveness

3.3.1.1 Quantitative Effects (Operation and Effect Indicators)

The amount of waste generated is calculated by inverse calculation based on the amount of waste collected and the collection rate. At the time of planning, two indices are set for measuring the quantitative effects of this project: the amount of waste collected and the rate of waste collected. The unit waste generated by one person per day is estimated based on the estimated volume of waste generated and the population in 2012, with a state-wide generation rate of 0.78 kg/person/day.¹³ The amount generated in 2012 was 4,980 tons, and the forecast for 2016 was 5,752 tons.¹⁴

In the Technical Cooperation Project Completion Report, estimates of the amount of waste generated (amount of waste) are calculated using the following methods.

1) Estimation Method for Waste Volume

Population x daily waste emissions per person (basic unit)

2) Population Estimation Methods

Population projections are estimated from historical trends throughout Khartoum State and are calculated by multiplying the population of each LCA by the rate of increase or decrease in historical trends throughout Khartoum State.

3) Method of Estimating Daily Waste Emissions per Capita (Basic Unit)

It is assumed that the LCAs (Khartoum, Omdurman, Bahary) in central Khartoum will rise by 1.5% each year, while the other LCAs (Um Badda, Jabal Aulia, Sharg En Nile, Karary) will rise by 1.2% each year.

Interviews with SACKS¹⁵ (currently KCC) and the localities were conducted, and the waste collection rate (collected volume ÷ generated volume) was set at 65% for the entire state. This is judged from the population, the amount collected, the basic unit, the number of collection vehicles, and the collection implementation conditions (the number of trips of collection vehicles).¹⁶ It is mentioned, "The amount of waste collected as of October 2016 was 3,727 tons/day, and the largest amount of waste collected so far was 4,217 tons/day in March 2016. Although the index has not been achieved at this time, the amount of waste collected is trending upward;" and the figure has

¹² Sub-rating for Effectiveness is to be put with consideration of Impacts.

¹³ Preparatory Survey Report

¹⁴ Ex-ante Evaluation table

¹⁵ Supervisory Authority for Cleaning in Khartoum State

¹⁶ Preparatory Survey Report

reached 80-90% of the target value.¹⁷

The equipment provided in this project started to be used in March 2016, but the amount of waste collected did not increase as much as expected. One of the factors behind this is that the utilization rate of container vehicles was low. The number of containers provided by the Japanese side was 2 per vehicle, which was considered to be the minimum, and the remainder was the burden on the Sudan side. The KCC had already ordered 100 containers, but as of January 2017, only 20 had been delivered, not making full use of container vehicles. With these additional containers, the estimate based on past actual values was to achieve the index (4,600 tons/day) in August 2017.¹⁸

In the field survey, data on estimated waste generation (tons/year), waste collection (tons/year), and waste collection rate (%) of each locality were provided by the KCC. The data are shown in Table 6.

Table 6 Quantitative Effects: [Operation Indicator] Waste Collection Volume and [Effect Indicator] Waste Collection Rate

Item	LCA	2015	2016	2017	2018	2019	2020
Estimated population of each locality	Khartoum	777,381	796,557	815,633	834,573	853,343	871,912
	Bahary	737,210	755,976	774,911	793,994	813,215	832,560
	Jabal Aulia	1,149,199	1,180,441	1,212,212	1,244,503	1,277,329	1,310,689
	Karary	869,270	892,364	915,778	939,494	963,506	987,799
	Omdurman	622,255	638,217	654,324	670,559	686,911	703,368
	Sharg En Nile	1,059,172	1,088,106	1,117,558	1,147,510	1,177,961	1,208,899
	Um Badda	1,201,235	1,233,846	1,267,153	1,301,151	1,335,863	1,371,296
Estimated total population of seven localities	Total	6,415,722	6,585,507	6,757,569	6,931,784	7,108,128	7,286,523
Estimated waste generation in each locality (tons/year)	Khartoum		499,224	519,280.8	519,354	557,718	579,488
	Bahary		230,214	242,621.4	264,252	283,695	294,840
	Jabal Aulia		293,166	358,387.2	358,314	385,758	401,128
	Karary		260,592	230,872.8	239,946	247,955	257,712
	Omdurman		252,906	304,475.4	304,512	326,933	339,612
	Sharg En Nile		222,894	242,182.2	242,292	260,775	271,180
	Um Badda		346,236	270,847.3	270,840	291,724	303,576
Estimated total waste generation in seven localities	Total		2,105,232	2,168,667	2,199,510	2,354,558	2,447,536
Waste collected in each locality (tons/year)	Khartoum		324,276	441,787	282,344	265,316	236,472.4
	Bahary		138,348	161,967.1	113,704.4	87,804	46,388.57
	Jabal Aulia		199,104	90,541.7	100,312.9	52,639	45,614.61
	Karary		183,366	92,172.1	104,748.3	91,783	77,227.87
	Omdurman		172,020	189,498.6	220,154.6	177,100	137,826

¹⁷ Technical Cooperation Project Completion Report

¹⁸ Technical Cooperation Project Completion Report

	Sharg En Nile		133,956	103,788.9	104,382.7	91,025	811,28.87
	Um Badda		177,144	111,320	154,675.2	110,303	76,650.39
Total waste collected in seven localities (tons/year)	Total		1,328,214	1,191,075	1,080,322	875,970	701,309
Total waste collected in seven localities (tons/day) ¹	Total		3,639	3,263	2,960	2,400	1,921
Waste collection rate (%) in each locality	Khartoum		65%	85.1%	54.4%	47.6%	40.8%
	Bahary		60%	66.8%	43%	30.9%	15.7%
	Jabal Aulia		68%	25.3%	28%	13.6%	11.4%
	Karary		70%	39.9%	45.4%	37%	30%
	Omdurman		68%	62.2%	72.3%	54.2%	40.6%
	Sharg En Nile		60%	42.9%	43.1%	34.9%	29.9%
	Um Badda		51%	41.1%	57.1%	37.8%	25.2%
Waste collection rates for all seven localities as a whole	Overall		63.1%	54.9%	49.1%	37.2%	28.7%

Source: Data provided by the KCC

Based on the data provided, calculations of the waste collected (tons/day) since 2017 show that the amount of waste collected has been decreasing every year.

Table 7 Operation Indicator (Waste Collection Volume)

	Baseline	Target	Actual			
	2012	2017	2017	2018	2019	2020
		1 Year After Completion	1 Year After Completion	2 Years After Completion	3 Years After Completion	4 Years After Completion
Waste collected (tons/day)	3,200	4,600	3,263	2,960	2,400	1,921

Sources: Materials provided by JICA, provided by implementing organizations, etc.

The estimated population of the seven localities shown in Table 6 has increased, and with this, the amount of waste generated has also increased. On the other hand, as shown in Table 6 above, the amount of waste collected has been decreasing, and the rate of waste collection has been decreasing since 2017. The following are factors for the decline. In Sudan, domestic security deteriorated (container carriers destroyed by protest groups) due to the political change that occurred in April 2019, and safe waste collection operations were difficult and the services were stagnant. Although security later recovered¹⁹, waste collection vehicle operation has become difficult due to the surge in fuel prices.

¹⁹ In Sudan, a political upheaval by the military occurred in October 2021, raising concerns about the deterioration of security again.

[Operating status of provided equipment]

In this project, a total of 98 units (42 compactors and 56 container carriers) were provided in the equipment procurement (Lot-1) and additional equipment procurement (Lot-3). In addition, 3 bulldozers, 3 excavators, and 1 water supply truck were provided as equipment for the final disposal sites. Table 8 and Table 9 show the numbers of equipment deployed and their operating status.

Table 8 Operating Status of Equipment provided to this Project for Each LCA

Unit: Vehicle

Item	LCA	Number of vehicles provided	In operation	Under repair	Cannot be repaired	Disposal
Compactor	Khartoum	5	4	1	0	0
	Bahary	5	5	0	0	0
	Jabal Aulia	7	4	2	1	0
	Karary	5	3	0	2	0
	Omdurman	5	3	2	0	0
	Sharg En Nile	6	6	0	0	0
	Um Badda	5	5	0	0	0
	KCC (hospital)	4	4	0	0	0
Container Carrier	Khartoum	6	6	0	0	0
	Bahary	7	7	0	0	0
	Jabal Aulia	7	3	3	1	0
	Karary	6	6	0	0	0
	Omdurman	6	5	1	0	0
	Sharg En Nile	7	5	0	1	1
	Um Badda	6	6	0	0	0
	KCC (hospital)	11	11	0	0	0

Source: Data provided by the KCC

Table 9 Operating Status of Equipment Provided to Final Disposal Sites

Unit: Vehicle

Item	Final disposal site	Number of vehicles provided	In operation	Under repair	Cannot be repaired	Disposal
Bulldozer	Khartoum	1	0	0	1	0
	Bahary	1	0	0	1	0
	Omdurman	1	0	0	1	0
Excavator	Khartoum	0	0	0	0	0
	Bahary	1	0	0	1	0
	Omdurman	1	1	0	0	0
Water-supply truck	Khartoum	1	1	0	0	0
	Bahary	0	0	0	0	0
	Omdurman	0	0	0	0	0

Source: The KCC provided data (* One water truck is used on dispatch to each final disposal site.)

Table 10 Operation Status of Vehicles Provided to this Project
(as of the site survey in August 2021)

Vehicle	Number of vehicles provided	Number of vehicles in operation	Operation rate
Compactor	42	34	81.0%
Container Carrier	56	49	87.5%
Bulldozer	3	0	0.0%
Excavator	2	1	50.0%
Water-supply truck	1	1	100.0%

Table 11 Effect Indicator (Waste Collection Rate)

	Baseline	Target	Actual			
	2012	2017	2017	2018	2019	2020
		1 Year After Completion	1 Year After Completion	2 Years After Completion	3 Years After Completion	4 Years After Completion
Waste Collection rate	65%	80%	55%	49%	37%	29%

Source: Data provided by the KCC

In the evaluation of effectiveness, the amount of waste collected, an operational indicator of quantitative effects, was 1,921 tons/day in the results for 2020, which is not within the target value of 4,600 tons/day, and is also down from the baseline of 3,200 tons/day (2012). As a result, the waste collection rate, an effect indicator, declined, and was 29% in 2020 compared to the target value of 80%. As of January 2017, the company was on track to reach its target, and in 2017, it achieved 3,263 tons/day, which is 71% (3,263 tons/day ÷ 4,600 tons/day) of the target. Afterwards, it became impossible to maintain the quantitative effect because the waste collection vehicles,

etc., could not be utilized sufficiently due to the effects of insufficient funding and fuel shortage. When we look at the rate of achievement of the waste collection rate, which is an effect index, against the target value of 80%, it is 36.3% ($29\% \div 80\%$). However, since the confirmation schedule of the effect of the project target at the time of planning is made one year after the completion of the project, the ex-post evaluation is judged based on the actual results one year after the completion of the project (2017) as described in the ex-ante evaluation table. In 2017, the waste collection rate was 55%, which is 69% of the target ($55\% \div 80\%$). Therefore, at one year after completion of the project, the achievement rate of the operational indicator (waste collection amount) was 71%, and the achievement rate of the effect indicator (waste collection rate) is 69%.

3.3.1.2 Qualitative Effects (Other Effects)

As a qualitative effect, the indicator set at the time of planning was “Improving the amount of waste collected improves the state’s hygienic environment.”

The authors interviewed staff members of three final disposal sites (Khartoum, Bahary, and Omdurman) and neighboring residents via field surveys regarding bad smell, insect pests, and smoke damage. The staff responded that all of the three final disposal sites had reduced bad smell, insect pests, and smoke damage compared to 2016 or earlier. This was thanks to introducing bulldozers, which were effective in regular soil covering. On the other hand, according to the interviews at the Khartoum final disposal site, there were replies that illegal dumping around the disposal site had relapsed in 2020 and 2021, although it had been improved in 2017. This is related to the dissatisfaction due to waste collection vehicles not collecting in locations citizens desire (around each detached house or along branch roads in residential area), because of the lack of fuel and the lack of the number of vehicles in operation. The shortage of the number of heavy machinery units and the shortage of fuel are also cited as contributing factors therein. All of the three bulldozers provided in this project are broken and not operational, and only one of the two excavators is operational. The KCC procures its own heavy machinery and deploys it to the final disposal site, but it says that further equipment is necessary for sufficient operation of the final disposal site.

According to the interviews with the staff at the final disposal site, bad smell, insect pests, and smoke damage are decreasing, and the effects of this project are being noticed. However, it seems difficult to recognize the improvements because the neighboring residents have a negative image about the existence of the final disposal site itself. In order to satisfy the demands of the neighboring residents and further improve the surrounding environment, there are issues such as sufficient deployment of heavy machinery and securing of fuel for operation.

The results of interviews with staff involved with the facilities and neighboring residents in the

final disposal site²⁰, the produce market²¹, and the residential area²² where waste is collected are shown below.

(1) Sanitary environment around the final disposal site

a. Generation of bad smell, insects, etc.

Interviewee	Issue
Khartoum disposal site staff	Bad smells have been mitigated by the soil cover with the donated bulldozer compared to 2016 and earlier. On the other hand, insects (flies, mosquitoes) are still present due to the existence of nearby poultry farms. It is necessary to spray pesticides.
Residents in the vicinity of the Khartoum disposal site	There has been no change since before 2016. The bad smell from the disposal site is severe, and a lot of insects are generated.

b. Smoke damage caused by the spread of waste fire

Interviewee	Issue
Khartoum disposal site staff	Before 2016, fire spread and smoke damage was frequent, but now they are obviously decreasing due to the use of donated vehicles to cover soil by staff for firefighting.
Residents in the vicinity of the Khartoum disposal site	There has been no change since before 2016. Residents are affected by smoke damage both day and night. The person responsible for the disposal site is not managing it properly, and the waste collectors in the disposal site live by the burning area.

c. Issues for improving the hygienic environment

Interviewee	Issue
Khartoum disposal site staff	Further improvements necessitate the deployment of a sufficient number of heavy machineries, a fuel supply, and proper maintenance. Illegal dumping decreased in 2017, but increased again in 2020 and 2021. Deployment of work machinery and supply of fuel are the most important tasks to further improve the operation of final disposal sites, and operation costs are necessary for this purpose.
Residents in the vicinity of the Khartoum disposal site	Though there is no concrete measure to prevent bad smell, it is necessary for the person responsible for the disposal site to carry out the control perfectly. As for the spread of fire, quick soil covering is necessary. Illegal dumping decreased in 2017, but increased again in 2020 and 2021. The state government should respond responsibly to the disposal site issue. Insect generation requires the application of insecticides.

²⁰ Six persons (2 persons × 3 places) of the final disposal site were targets.

²¹ 14 persons related to the produce market (2 persons × 7 places in each locality) were targets.

²² 21 residents (3 persons/point × 7 places in each locality) in the vicinity of the waste collection points were targets.

(2) Hygienic environment around the produce market

Item	Situation
Scattered waste	<p>The situation before 2016 was not good, but it was improving until 2018, but has since become worse than it was before 2016.</p> <p>In the past, LCAs sent many cleaning workers to clean the inside of the market regardless of the time of day and night, but no workers are being sent to the market presently. Political changes taking place in Sudan have adversely affected waste management.</p> <p>On the other hand, there is also a produce market (Khartoum Central Market) which evaluates that the waste collection is carried out every day.</p> <p>Containers for waste should be located in a proper location for the produce market. It is also necessary to increase the frequency of collection.</p>
Bad smell	<p>Cleaning within the produce market is not being carried out, and the waste collection is infrequent, resulting in bad smell emanating from waste in containers.</p>

(3) Hygienic environment around the waste collection points

Item	Situation
Scattered waste	<p>If the containers remain full, the residents dispose of the waste around the containers. It is necessary to increase the frequency of container collections and prevent the containers from becoming full.</p>
Bad smell	<p>Bad smells are generated when container collection is delayed. The effect of rainfall is also large.</p>

3.3.2 Impacts

3.3.2.1 Intended Impacts

Though the confirmation items of the impact of this project were not set at the time of planning, in carrying out this ex-post evaluation, the following two items were set as confirmation items: (1) the implementation status of the Master Plan, and (2) the state of contribution to the stability of civilian life.

(1) Implementation status of the Master Plan

The framework of the Master Plan revised in the Technical Cooperation Project is as follows.

Target year	2028
Target waste	Targets non-industrial waste generated from the state of Khartoum. Medical waste, industrial waste, etc., shall not be covered by the plan.
Purpose	<ol style="list-style-type: none"> (1) Expand the coverage area of collection and transportation to prevent illegal dumping. (2) Provide better waste management services to meet the needs of residents and businesses. (3) Improve the waste collection rate. (4) Introduce efficient recycling systems such as waste separation and weight reduction in cooperation with resident organizations. (5) Provide collection services for construction and oversized waste. (6) Improve collection efficiency and reduce subsidies from state governments. (7) Introduce privatization of waste management.

Compactors and container carriers provided in this project are divided into vehicles for collecting non-industrial waste and vehicles for collecting medical waste. In accordance with the Master Plan, each LCA collects non-industrial waste. For LCAs with relay stations within their jurisdiction, waste collected with compactors or container carriers is transported to the relay stations, and then transported to final disposal sites within their jurisdiction by large dump trucks.²³ In Khartoum State, industrial and medical wastes are not transported to relay stations, but are transported directly to the Omdurman final disposal site. Collection of non-industrial waste, medical waste, and industrial waste is divided and handled, and efforts are made in accordance with the Master Plan. On the other hand, there are issues with the operation of the waste collection vehicles, and the waste collection rate is not improving.

<Handling of medical waste>

Medical waste is managed by the KCC, collected from the hospital, and transported to the final disposal site. Originally, medical waste is transported from hospitals, etc., to incineration processing facilities operated by private contractors, and the processed waste is transported to final disposal sites for landfill. The waste collection vehicles provided in this project also carry waste that is disposed of as non-industrial waste from hospitals, etc. However, some of this waste, which is disposed of as non-industrial waste, contain medical waste (case examples from the Omdurman final disposal site).

In the final disposal site, medical waste landfilling is carried out by demarcating the medical waste landfill area from the non-industrial waste landfill area. The traffic lines in the premises for vehicles carrying medical waste are operated in a way such that they are separate from vehicles carrying non-industrial waste and there are no mistakes in the landfill area. Delineating landfill areas improves the hygienic environment of those that work with waste collection vehicles and disposal sites, as well as waste pickers.

Table 12 Medical Waste Collection Volume and Waste Collection Rate

Item	2016	2017	2018	2019	2020
Amount of waste from hospitals (tons/year)	27,038.5	49,158.3	61,428.4	72,014.9	73,636
Amount of medical waste (tons/year)	4,245.6	10,699.5	16,347	17,187.2	17,170.9
Waste collection rate (%)	38%	44%	51%	67%	70%

Source: Data provided by the KCC

²³ Non-industrial waste of LCA without relay station in the jurisdiction is carried directly to the final disposal site.

<Handling of construction waste soil, business waste, etc.>

Waste such as construction waste soil and timber is transported directly to the final disposal site without going through the relay facility. The waste from the produce market and by businesses is recovered preferentially because waste collection charges can be collected.

(2) The state of contribution to the stability of civilian life

Below are the results of interviews with the market officials and residents neighboring the produce market and waste collection sites.

<Interview in the produce market>

When interviews were conducted in the produce markets within the seven LCA jurisdictions, some responded that they were improving (3 markets) and some responded that they were not improving (4 markets) in comparison to 2016 and earlier. They said that there are bad smells, especially when it rains. Also, to improve the situation, it is necessary to increase the frequency of waste container collection.

<Interviews with residents in the vicinity of waste collection sites>

Illegal dumping in residential areas is on a household basis and therefore will not be disposed of in large quantities at a time. However, if waste collection is not regularly carried out (once every two or three days, irregularly), waste is disposed of around full containers at collection points, and waste is discarded before empty containers are in place. Incidentally, type specific waste collection has not been carried out. In the case of waste collection in residential areas in the Karary district, there had been collection from each house when the project began, but presently, each house is collected from once every two days (weekdays are unscheduled). The LCAs prevent waste scattering into the surrounding area by placing empty containers at the same time as collecting full containers.

3.3.2.2 Other Positive and Negative Impacts

(1) Impacts on the Natural Environment

The construction site of the Central Workshop is state government land and not part of a national park, so it is judged that there is no negative impact on the natural environment and there are no problems. According to the KCC, a distance from the surrounding residential area was maintained, so there were no issues such as noise from construction work. According to the consultant in charge of construction supervision, during the construction of the Central Workshop, monitoring was carried out by the construction contractor in accordance with the monitoring form, and the report was made to the head contractor and JICA in a monthly report.

The wastewater treatment in the Central Workshop is carried out with underground osmotic

treatment. Wastewater from toilets and offices is designed to flow into the osmotic tank through the excreta treatment tank, and wastewater containing oil from the workshop and car wash is designed to flow into the osmotic tank through the oil-water separation tank; the wastewater is treated properly.

In the collection of waste, records are taken regarding the amounts carried in at relay facilities and final disposal sites, respectively, as a procedure to prevent illegal dumping. Field surveys showed that efforts were made to prevent the scattering of waste, such as placing empty containers at the same time as collecting containers at waste collection sites, and waste collection workers collecting waste scattered outside of the containers.

(2) Resettlement and Land Acquisition

As mentioned above, since the land belongs to the state government, no relocation of residents or acquisition of new land sites occurred.

(3) Unintended Positive/Negative Impacts

The final Omdurman disposal site accepts medical-related waste and landfills them. At the final disposal site, they explained to the waste pickers that they would not enter the landfill area of medical waste. At the time of the site survey, no waste picker was observed in the medical waste landfill area. There were no issues between the final disposal site and the waste pickers on-site. The response of the disposal site staff was made with consideration to the safety of the waste pickers, and there was no effort to remove them. Waste pickers often attach themselves to waste delivery vehicles to sort waste, and they are warned to ensure that there are no accidents with vehicles. The waste pickers at the relay centers promise to leave the relay station at 3:00 PM. On the other hand, according to interviews with residents near the Khartoum final disposal site, they feel uneasy about drunken waste pickers coming into the village at night and watching TV through the windows of resident's homes and similar behaviors. Though the behavior of these waste pickers cannot be said to be attributable to this project, it is a fact that many waste pickers are in the area due to the presence of final disposal sites. In order to operate the final disposal site continuously with the understanding of the residents, it seems necessary to take measures in cooperation with the administration so as not to cause anxiety among the residents in the area.

Regarding the impact evaluation, when looking at the effects on improving the sanitary environment, the problems of bad smell and insect pests occurring currently are more noticeable than the comparison of the past and present, according to interviews with local residents, which is thought to make, the effects of the environmental improvement felt by the staff at the final disposal site, difficult to see.

This project has achieved its objectives to some extent. Therefore, effectiveness and impacts of the project are fair.

3.4 Sustainability (Rating:②)

3.4.1 Institutional/Organizational Aspect of Operation and Maintenance

In Khartoum State, the LCAs of the seven localities are responsible for waste collection and transport operations under the guidance control of the KCC, and also under the direction of HCENR.

The organizational chart of the KCC is shown in Fig. 1.

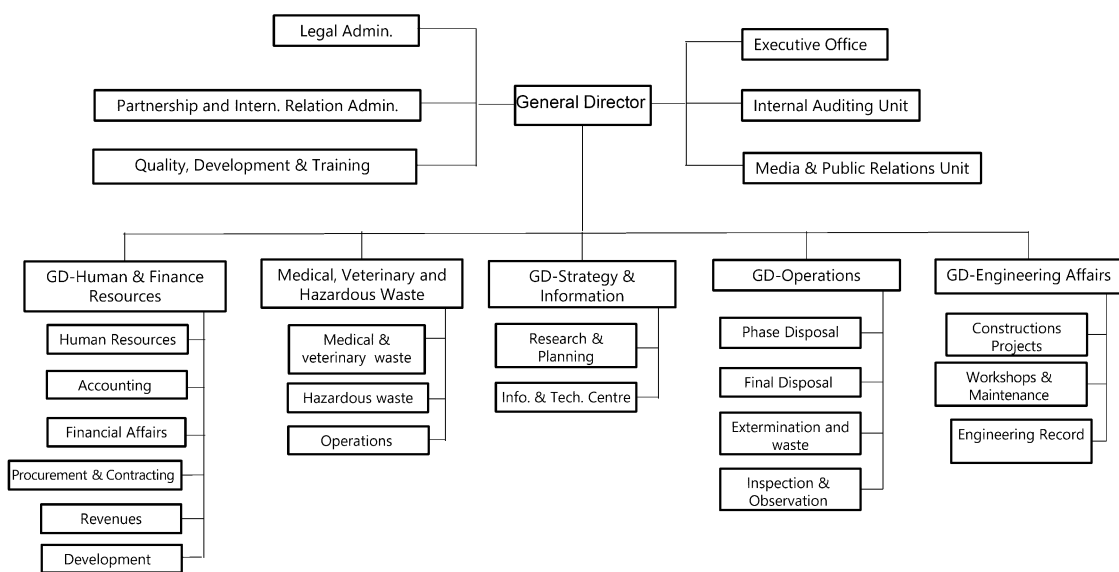


Fig. 1 The KCC Organizational Chart

Source: Data provided by the KCC

At the completion of the project, 10 equipment maintenance personnel were assigned to the Central Workshop. Of these, six persons were stationed at the Central Workshop, and the other four persons were also performing the maintenance of vehicles and heavy machinery in the relay facilities and the final disposal site (JICA materials²⁴). According to the hearing in the field survey, at present, a total of six persons, one director and five mechanics, are stationed in the Central Workshop, and mechanics are dispatched from the Central Workshop to disposal sites and relay facilities when necessary. The system in the initial plan is almost entirely maintained, and it seems to be sufficient. Regarding the Central Workshop and final disposal sites, the system is maintained under the KCC control. For waste collection at each LCA, the state government subsidizes 50% of the personnel expenses of LCA. LCA maintains the system by securing the personnel cost with

²⁴ Defect Inspection Report (Lot-2 facility construction) May 2017

the personnel cost subsidy from the state government and the income obtained from the waste collection business.

3.4.2 Technical Aspect of Operation and Maintenance

3.4.2.1 Technology for Operation and Maintenance of the Central Workshop

Maintenance technology at the Central Workshop is ensured (disassembly maintenance of vehicle engines is also possible). Basically, oil changes on the waste collection vehicles are to be carried out at the Central Workshop, and vehicle inspections of vehicles brought in from each LCA are also carried out at the same time. Vehicle repairs are available, and each LCA bears the cost of repair parts.

3.4.2.2 Challenges related to Vehicle Maintenance

According to the hearing from LCAs, simple repairs and maintenance of vehicles are carried out at workshops within the LCA. When major repairs are required, the vehicle is sent to the Central Workshop for repair. Though the procurement of repair parts is to be carried out by the LCA, there is a fiscal problem regarding the burden of this placed upon the LCAs. Parts that are inexpensive and distributed on the market can be procured by LCA, but repair becomes difficult when they need parts that are difficult to procure, such as those that are expensive and do not have distributors in Sudan.

According to an LCA-based interview, although there are manufacturer dealers in Sudan, it is difficult to procure repair parts for waste collection vehicles because they do not handle special parts for waste collection vehicles (compactor and container carrier specific parts, hydraulic pumps, electrical system, etc.).

The Central Workshop will repair the vehicle, but since each LCA will procure repair parts, there are problems in import procedures and funding. If a large number of spare parts is procured, the state government will make bids and decide on an import company. Even if the amount is small, spare parts can be procured by passing through an import company, but it is necessary to prepare a prepaid amount equivalent to 50% of the procurement price, and it is difficult to prepare prepaid amount by LCAs when the parts are expensive.

3.4.2.3 Issues with Waste Collection Vehicles

Compactor and container carrier failures are concentrated in the same place (rear-gate operating parts, container fixing parts, electrical system, diesel pump, etc.). The cause of the failure is that the burden on the car body is large when it is filled with waste, because road conditions are not good. The large amount of waste in containers makes them heavier and weighs down the container carrier. Compared with 2016, the number of operating vehicles is decreasing. It seems that vehicle failures are also caused by carrying out operations for long periods with fewer vehicles.

When these are comprehensively considered, one can judge that the technology for operation and maintenance is being ensured, though there is a problem in the procurement of repair parts.

3.4.3 Financial Aspect of Operation and Maintenance

3.4.3.1 The KCC's Financial Status

As for the KCC's financial status, we obtained information for the three years from 2016 to 2018 for revenue data and for the five years from 2016 to 2020 for expenditure data. From 2016 to 2018, income exceeded expenditure. Support and subsidies account for more than half of the income.

Table 13 The KCC Financial Status

Unit: SDG (Sudanese Pound)

Fiscal Year	Income	Expenditure	Balance of Payments
2016	21,999,560	15,299,881	6,699,679
2017	39,900,487	19,338,047	20,562,440
2018	67,318,044	30,663,791	36,654,253
2019	-	69,212,035	-
2020	-	89,031,652	-

Among the expenditures, the proportion of fee for fuel and oil for vehicles and non-vehicles is high, accounting for 30% to 40% of the expenditures. In addition, these fees, combined with maintenance costs for vehicle and transport equipment, account for 60% to 70% of all expenditures.

3.4.3.2 Financial Status of Each LCA

The equivalent of 50% of the personnel expenses for each LCA is subsidized by the state government, and the system is being maintained. Additionally, they were subsidized by localities for fuel for the vehicles, but they said that it was insufficient due to rising fuel prices. According to a hearing from the LCA, the price of fuel in 2020, which was 300 SDG/gallon, was 1,450 SDG/gallon in 2021. The financial status of each LCA is shown in Table 14.

Table 14 Financial Status (Income and Expenditures) of Each LCA

LCA	Item	Currency unit: SDG (Sudanese Pound)				Converted to JPY
		2017	2018	2019	2020	(SDG1=1.658 yen)
Khartoum	Income	N.D.	55,717,661	71,573,500	115,884,929	192,137,212 yen
	Expenditure	N.D.	37,755,304	67,610,993	117,616,839	195,008,719 yen
	Income/Expenditure (%)	-	148%	106%	99%	
Bahary	Income	N.D.	N.D.	N.D.	N.D.	
	Expenditure	N.D.	N.D.	N.D.	N.D.	
	Income/Expenditure (%)	-	-	-	-	
Jabal Aulia	Income	N.D.	N.D.	28,437,299	24,894,350	41,274,832 yen
	Expenditure	N.D.	N.D.	12,248,338	17,965,323	29,786,506 yen
	Income/Expenditure (%)	-	-	232%	139%	
Karary	Income	8,748,546	19,345,093	21,043,409	23,221,304	38,500,922 yen
	Expenditure	253,170,600	435,121,036	12,091,428	15,025,355	24,912,039 yen
	Income/Expenditure (%)	-	4%	174%	155%	
Omdurman	Income	N.D.	34,671,230	37,220,608	43,493,054	72,111,484 yen
	Expenditure	N.D.	30,037,648	34,976,132	43,600,154	72,289,055 yen
	Income/Expenditure (%)	-	115%	106%	100%	
Sharg En Nile	Income	N.D.	N.D.	N.D.	N.D.	
	Expenditure	N.D.	N.D.	N.D.	N.D.	
	Income/Expenditure (%)	-	-	-	-	
Um Badda	Income	N.D.	38,332,226	27,207,354	34,447,156	57,113,385 yen
	Expenditure	N.D.	31,771,000	30,353,020	31,495,742	52,219,940 yen
	Income/Expenditure (%)	-	121%	90%	109%	

Looking at the situation of the five LCAs which is shown in financial data in the table above, the balance of income and expenditure is positive, which is thought to be due to spending being kept down in line with income. When comparing the change in the income for each fiscal year converted to yen, at the exchange rate at the time of the Preparatory Survey in 2014, Khartoum LCA had an income of 301 million yen (SDG1 = 22.401 yen), but at the rate in 2020, it was 192 million yen (SDG1 = 1.658 yen *JICA average rate from December 2020 to March 2021), which is only 64% of the 2014 amount. In addition, a similar comparison in Um Badda LCA shows that it was 57 million yen in 2020 compared with 203 million yen in 2014, which is 28% of that in 2014.

3.4.3.3 Issues of Garbage Collection Fee Collection Rate

LCAs operate the waste collection business using the waste collection fees collected from residents and enterprises as an income. Case example of hearings with residents and companies on the ratio of waste collection fees and collection rate are shown below.

Table 15 Case Examples of Rate of Waste Collection Fees and Collection Rate

LCA	Collection fees collection points	Percentage in revenue	Collection rate	Remarks
Omdurman	Residents	15%	10%	125 SDG – 500 SDG Decided by state government assembly (depending on the area).
	Commercial area	85%	90%	Decided by state government assembly.
Um Badda	Residents	10%	9%	93% (collection rate in 2018)
	Commercial area	90%	78%	

According to Omdurman LCA, the estimated revenue was 17,000,000 SDG per month. On the other hand, the cost of fuel oil for vehicles alone was 12,000,000 SDG per month.

According to Um Badda LCA, the collection rate of waste collection fees in 2018 was good, and the income and expenditure were balanced. Later, the use of vehicles for a long period of time resulted in problems in the vehicles, fuel costs soared, and the number of operational vehicles decreased. After 2019, collection from houses had changed to collection services along major roads.

The breakdown of the LCA income according to interviews from each LCA was that, when comparing the ratios of waste collection fees from resident households, and businesses and markets in commercial areas, 80-90% of the revenues are from businesses and markets.

The collection rate of waste collection fees from residential households is low, at around 10%, and the collection rate from businesses and markets is as high as 80-90%. In order to improve the financial status of LCAs, it is necessary to improve the collection rate from residential households, and for that purpose, it is necessary to proceed in a set with the improvement of the services of waste collection.

Considering the above points, we judge that the financial situation is becoming worse each year after the project is completed. Fluctuations in exchange rates have made it particularly difficult to purchase imported products. It is difficult to curb expenses for activities such as vehicle fuel costs, but we believe it is possible to increase income by improving waste collection services. Some of the LCAs are working to improve services by collecting waste from each house amid a severe financial condition. At present, the rate of fee collection from residential households is low, but in other words, it includes the possibility to increase income.

3.4.4 Status of Operation and Maintenance

3.4.4.1 Operation Status

The table below shows the operation status of each LCA from interviews.

Table 16 Operation Status of Each LCA

LCA	Number of staff	Operation	Collection method
Khartoum	Unknown	●3 weekly (average) waste collection	●3 weekly (average) waste collection
Bahary	Unknown	●Three-shift system ① 7 :00-15 :00 ② 15 :00-20 :00 ③ 22 :00-4 :00 ●7-day week, almost 24H (not all day on Fridays)	●In the downtown area, 2 times (fixed day of the week)/week, irregular collection times, 80% collecting at each house, and 20% collecting at collection points. ●In rural areas, once per week, fixed collection times. ●The market has daily collection.
Jabal Aulia	Unknown	3-shift 24H: 8H x 3-shift (Friday is a holiday, but there is light work such as cleaning of vehicles)	●Garbage collection along major roads. ●Daily collection on major roads, twice weekly collection for branch roads.
Karary	●Over 500 staff (staff + drivers)	●6-day week (Friday holiday) ●Since three months ago, a 2-shift system. 7:00-15:00, 16:00-22:00 ●Waste from the market is collected after 22:00.	●Residential areas are collected every two days. ●For the market, etc., twice a day.
Omdurman	●770 staff (101 of which are fee collection teams)	●7-day week (Friday: 50% (rolling stock) operation), 24H, 3-shift system ●3-shift system ① 7:00-15:00 ② 15:00-18:00 ③ 19:00-2:00	●Commercial areas and areas along the main roads (including residential areas) are also collected during night time hours.
Sharg En Nile	Unknown	● 6-day week (except Friday), 8-hour work system with 1-shift system (because of insufficient salary).	● Collected daily along major roads, along branches, and in the market.
Um Badda	● 945 staff (147 of which are fee collection teams)	6-day week, 2-shift system. Friday is one shift to 14 o'clock.	● Collection point method ● Daily patrols of main and branch roads (from July 2021) ● Market (3 locations) 24H gathering

Each LCA operates six to seven days a week with a shift system. Some LCAs operate at or near 24 hours. The frequency of waste collection varies according to LCA, such as daily collection in urban areas, and collection every 2-3 days. In most of the areas, the collection point method is carried out on main and branch roads, and there are a few areas where waste is collected at each house.

The collection method of residential district is different according to the district: waste collection at each house and at collection points. Because of requests from residents, collection at each house is carried out in some LCAs, and there is collection from each house about once a week, aiming at collection twice a week, but it has not been realized due to the lack of vehicles.

Regarding the frequency of waste collection, collection is carried out twice a week in residential areas, but according to interviews with residents, the collection dates are irregular. Residents request that collection services be provided to each house. Though there were some regions where the collection at each house had been carried out in the past, collection point method is currently becoming mainstream.

In the case of Omdurman LCA, two systems are adopted, namely the collection at individual houses and at collection points, depending on the district. In the collection point method, there is daily collection and collection every 2 days, and there are efforts to improve services in response to requests from residents.

In the produce market in each locality, collection is carried out daily, and multiple times, depending on the LCA. While the produce market “of course” has its needs, the high rate of collecting waste collection fees is probably linked to ensuring services.

An interview was made with the KCC about the operation status of the final disposal site directly controlled by the KCC. The final disposal site has an entrance gate, and security guards are deployed to manage the operation. They said that they set up a landfill compartment to accept the waste, excavate the compartment for the landfill, dump the waste, and cover the soil frequently. Staff members working at each final disposal site were also interviewed, and each issue is shown in the table below.

Table 17 Operation Status of Final Disposal Sites

Final disposal site	Operational challenges
Khartoum	<ul style="list-style-type: none"> • The machinery is insufficient. As an example, there is only one dump truck and loader, which is not sufficient. • Maintenance is performed very slowly.
Bahary	<ul style="list-style-type: none"> • The machinery is insufficient. • Fuel is insufficient.
Omdurman	<ul style="list-style-type: none"> • Fuel is insufficient. • Heavy machinery is defective. • Maintenance is performed very slowly. • If there is a problem with heavy machinery, it is necessary to share heavy machinery with other landfills.

3.4.4.2 Maintenance and Management Status

The operating status of waste collection vehicles, etc., provided in this project is as shown in Table 10 above. The operation rates of compactors and container carriers, which are waste collection vehicles, are high, and we consider that they maintain favorable conditions. On the other hand, there is no bulldozer in final disposal site currently in operation, and one of the two excavators is operational. Regarding waste collection vehicles, some are considered to be under repair and some are considered to be unrepairable, and, technically, there are those that are repairable at the Central Workshop, but the problem is in each LCA obtaining repair parts to bring

to the Central Workshop. There are special parts which are not distributed in the market, and there are problems in terms of prices and import processes. In addition, there is a problem with the durability of the vehicles on local roads and the same parts break across the rolling stock of waste collection vehicles.

Some minor problems have been observed in terms of the financial aspect and current status. Therefore, sustainability of the project effects is fair.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

This project aims to improve the capacity to collect and dispose of waste in Khartoum State, Sudan, by procuring waste collection and transport equipment and final disposal facility operation equipment, and by establishing a maintenance workshop to service waste collection and transport equipment, thereby contributing to improvement of the hygienic environment in the region. This project is consistent with the development plan and development needs of Sudan at the time of the ex-ante evaluation and the ex-post evaluation, and is consistent with Japan's ODA policy at the time of the ex-ante evaluation. Therefore, the relevance of this project is high. Regarding the project costs and the results of the project period, the project costs were kept within the plan, but the project period exceeded the plan, so the efficiency is fair. As for effectiveness, the achievement rate of the waste collection amount was 71% for the result one year after the completion of the project compared with the target value. The waste collection rate was 55% and the achievement rate was 69% in comparison with the target value of 80%. In addition, it can be said that the qualitative effect of suppressing the production of bad smell, insect pests, and smoke damage is observable in the responses of staff in the final disposal site. In terms of impact, there seems to be a positive effect on the surrounding hygienic environment, but the presence of final disposal sites is considered to be a negative factor for the neighboring residents, and the improvement is difficult to see due to the dissatisfaction with the current situation. Based on the above, although the targets expected via the project implementation have been achieved to a certain extent, the effectiveness and impacts are fair as there are some problems that can be seen in the expression of some after-effects. Regarding sustainability, while vehicle maintenance technology at the Central Workshop is maintained, problems are seen in parts procurement by each LCA. In addition, with each year since the completion of the project, it is becoming more difficult on the financial side due to the deterioration of security and fiscal instability in Sudan. Although the financial resources necessary for the continuation of the effects of the program and for the operation and maintenance of materials and equipment are currently insufficient, the program continues with limited financial resources. From these, the sustainability is judged to be fair.

In light of the above, this project is evaluated to be partially satisfactory.

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

<Regular waste collection>

The LCAs should carry out regular waste collection in order to prompt the residents to regularly dispose of waste. It is important to review the vehicle operation plan (including maintenance plan) in order to realize regular waste collection.

<Improvement of waste collection services in residential areas>

It is desirable for LCA to increase the area where there is collection at each house in addition to the collection point method in order to improve the waste collection services in the residential area.

<Strict collection of waste collection fees from residents>

In order for LCA to improve the collection rate of waste collection fees from residents, it is necessary to hear the opinions and requests of residents (periodic waste collection, improvement of collection methods, etc.), examine methods for improving the collection rate, and implement periodic fee collection.

<Maintenance cost assistance for waste collection vehicles>

It is recommended to subsidize the cost of procuring repair parts for waste collection vehicles, etc., managed by LCA.

<Dialogue with residents living near final disposal sites>

In order to eliminate the negative image about the final disposal site held by residents, it is desirable for the KCC to set up an opportunity to carefully explain to residents living in the vicinity of each final disposal site, the operation status of the final disposal site and activities such as covering soil and water sprinkling to improve the environment, as well as to listen to the requests from the residents. Then, it is possible to examine countermeasures such as spraying of insect repellent.

4.2.2 Recommendations to JICA

None

4.3 Lessons Learned

Selection of equipment considering local conditions

As described above in section 3.4.2.2 "Challenges related to Vehicle Maintenance," each LCA has difficulties obtaining repair parts when performing repairs to vehicles at the Central Workshop. Repair parts unique to waste collection vehicles and heavy machinery are not distributed in Sudan and are expensive. Then, as described in section 3.4.2.3 "Issues with Waste Collection Vehicles," the vehicles are burdened and the same locations malfunction due to running in poor road

conditions in the target area. From this point of view, it is desirable to select donation vehicles and equipment that facilitate on-site procurement of repair parts at the time of project Outline Design, and to select donation vehicles and equipment that are durable in consideration of local road conditions, etc.

Estimation that takes into account the capabilities of local contractors

As described in section 3.2.2.1 "Project Costs," bidding significantly exceeded the planned price at the first bidding of the Central Workshop construction, which resulted in a failure, and a second bidding was implemented. Therefore, the start of the Central Workshop construction work was delayed, and the whole project period was extended. This is considered to be due to the fact that, in the estimation of the project cost, the unit cost of construction was adopted, which was inexpensive, without fully considering the experience and ability of the local contractor. When utilization of local subcontractors is expected, it is desirable not only to pay attention to an inexpensive construction unit price, but also to set the unit price considering the actual results, experience, and ability of the local contractor, such as having experience in Japanese grant aid construction work.

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