

**Ex-Post Project Evaluation 2020:
Package II-5 (Sudan)**

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**JAPAN INTERNATIONAL COOPERATION AGENCY
CHUO KAIHATSU CORPORATION**

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The Republic of the Sudan

FY 2020 Ex-Post Evaluation on the Integrated Evaluation of
Grant Aid Project "Project for Upgrading Food Production Infrastructure in the Republic of
Sudan" and Technical Cooperation Project "Capacity Development Project for Irrigation
Scheme Management in River Nile State"

External evaluators: Chuo Kaihatsu Corporation: Isao Dojun, Takuya Itoh, Tatsuro Yokawa

0. Summary

In this ex-post evaluation, the evaluation of two projects (hereinafter referred to as "both projects") was carried out in an integrated manner. One of the projects evaluated in this report is the Grant Aid Project "Project for Upgrading Food Production Infrastructure in the Republic of Sudan" and this project was implemented to contribute to agricultural development in the River Nile and Kassala States by upgrading irrigation facilities and introducing equipment, etc. to ensure a stable supply of water for agriculture while also reducing the burden of operation and maintenance of irrigation facilities. The other project covered in this report is a technical cooperation project "Capacity Development Project for Irrigation Scheme Management in River Nile State." Based on the results of the above-mentioned Grant Aid Project, this project was implemented with the aims of strengthening the management capacity of Irrigation Management Organizations (IMOs) as well as facilitating appropriate irrigated agriculture in areas targeted by the irrigation scheme through agricultural-related improvements in accordance with an efficient water use plan. These two projects were aimed at improving irrigation facilities, water resource management capacity, and the technical skills of farmers. Both projects were in line with Sudanese policy priorities such as food security, increased agricultural productivity, and poverty reduction, as well as the need to improve irrigation facilities and strengthen operation and maintenance. These projects were also consistent with Japan's ODA policy toward Sudan, which had identified agricultural development as one of its top priorities. Therefore, the relevance of the two projects is high. The project purpose was largely met by improving irrigation facilities and strengthening their operation and maintenance (O&M) capacity, which improved the stability of agricultural water supply and increased the production and unit yield of major crops in irrigated areas. Furthermore, the overall goal of the Technical Cooperation Project has also been achieved. As a result, we can conclude that the project's effectiveness and impact are high. When both projects are evaluated as a whole, the project cost and duration were both within the planned budget and duration, indicating that the projects' efficiency is also high. As for the sustainability of the both projects, the technical capacity of IMOs in these projects' irrigation areas has been improved and the technical level has been maintained to some extent. There is a need to improve the financial situation by increasing the rate of water fee collection, and some irrigation canals

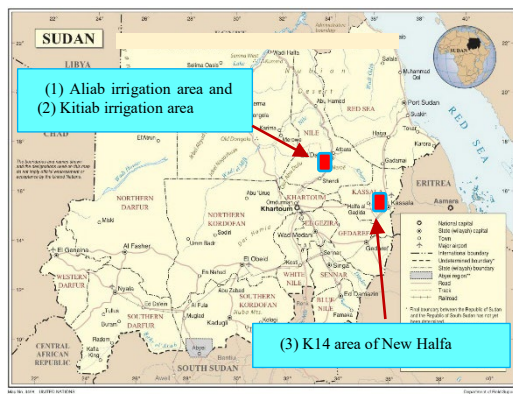
have been found to be in need of maintenance (primarily weeding). Therefore, the sustainability of the project is fair.

Considering the above, both projects are evaluated to be highly satisfactory.

1. Project Summary

The following is a summary of the Grant Aid Project "Project for Upgrading Food Production Infrastructure in the Republic of Sudan" and the technical cooperation project "Capacity Development Project for Irrigation Scheme Management in River Nile State."

A: Grant Aid Project "Project for Upgrading Food Production Infrastructure in the Republic of Sudan" and B: Technical Cooperation Project "Capacity Development Project for Irrigation Scheme Management in River Nile State"



Project Location Map

(Note: Three target areas of the grant aid project are the (1) Aliab irrigation area, (2) Kitiab irrigation area, and (3) K14 area of New Halfa; The two target areas of the technical cooperation project are the (1) Aliab irrigation area, and (2) Kitiab irrigation area.)

1.1 Background of Both Projects

Sudan's agricultural sector has been an important sector in the country, accounting for 31% of GDP and employing roughly 80% of the working population. Agriculture, however, was in retreat due to the land devastation and lack of infrastructure caused by Sudan's first civil war, which lasted from 1955 to 1972, and its second civil war, which lasted from 1983 to 2005, and even after that, the area of farmland did not expand and agricultural production remained stagnant over the long term, resulting in food shortages. Furthermore, with frequent droughts, domestic refugees, and an increase in food demand due to 2.24% annual population growth (World Bank 2008), it became necessary to increase food production to ensure domestic food security.

Irrigated agriculture accounts for roughly 60% of total grain production in Sudan (based on 2007 GDP), making it a critical factor in increasing agricultural production in Sudan. However, aging and inefficient irrigation facilities, low crop productivity, and high production costs have

all contributed to Sudanese agricultural products' low competitiveness in both domestic and international markets. To address this situation, the Sudanese government formulated *the Executive Programme for Agricultural Revival ("EPAR," 2008-2011)* and *the National Wheat Production Project ("NWPP," 2009/2010-2013/2014)* to promote the rehabilitation of irrigation facilities in the main irrigation schemes for ensuring food security, improve agricultural productivity, reduce poverty, and increase income. In Sudan, the effects of climate change, including the recent rainfall decreases and temperature increases, are becoming more serious in the country. As a result, there has been an increase in demand for stable access to water for agriculture via irrigation infrastructure development in order to improve resilience to the effects of climate change and reduce the impact of flood risks.

Given these circumstances, the Government of Sudan, through the fourth Tokyo International Conference on African Development (TICAD IV) has requested support from the Government of Japan for the development of irrigation facilities, management of water resources, and production improvement of rice, wheat, and other crops to promote Sudan's EPAR and NWPP initiatives.

In response to this request, a plan was formulated for Aliab and Kitiab in River Nile State as well as the K14 area of New Halfa in Kassala State. Based on this, a Grant Aid Project for irrigation facility development was implemented from October 2012 to November 2015. In addition to this Grant Aid Project, a technical cooperation project called the "Capacity Development Project for Irrigation Scheme Management in River Nile State" was also implemented from November 2015 to November 2019. The purpose of the project was to improve the management capacity of IMOs, as there was a need to improve farming practices in line with more efficient water use planning and to strengthen the soft component of irrigation management.



1.2 Project Description

A: Grant Aid Project: "Project for Upgrading Food Production Infrastructure in the Republic of Sudan"

The project aims to enable stable irrigation water supply and reduce operation and maintenance burden of irrigation facilities by updating irrigation facilities and equipment in River Nile and Kassala states, thereby contributing to the agricultural development in both states.

Grant Limit/Actual Amount	3,045 million yen/2,829 million yen
Exchange of Notes (E/N) and Grant Agreement Signing Dates	October 7, 2012/October 7, 2012
Implementing agency	International Cooperation & Investment Directorate, Federal Ministry of Agriculture and Irrigation (currently, International Cooperation Directorate, Federal Ministry of Agriculture and

		Natural Resources), etc.
Project completion		November 2015
Project areas		Aliab and Kitiab areas in River Nile State, K14 area of New Halfa in Kassala State
Project work implementor	Main entity	Konoike Construction Co., Ltd.
	Consultant	Sanyu Consultants Inc.
Preparatory Survey		March 2011-April 2012
Related projects		Capacity Development Project for Irrigation Scheme Management in River Nile State (CADEPIS-RNS)

	
Pump station's interior constructed with the Grant Aid Project (Aliab Pump Station)	Citrus farmland of a fruit tree producing farmers' group in the Kitiab scheme supported by the Technical Cooperation

B: Technical Cooperation Project: Capacity Development Project for Irrigation Scheme Management in River Nile State

Overall Goal		Agricultural production in the target irrigation schemes is increased.
Project Purpose		Improved irrigated agriculture is practiced in the target irrigation schemes.
Outputs	Output 1	Institutional capacities of IMOs are enhanced to manage the irrigation system.
	Output 2	Capacities of IMOs are improved to conduct appropriate operation and maintenance of irrigation facilities.
	Output 3	Effective measures are developed to improve water distribution.
	Output 4	Effective methods are developed as a model for improved farming

		techniques.
Japan side project cost		423 million yen
Project period		November 2015-November 2019
Project areas		River Nile State: Aliab Irrigation Scheme (2,205 ha) and Kitiab Irrigation Scheme (2,394 ha)
Implementing agency		International Cooperation & Investment Directorate, Federal Ministry of Agriculture and Irrigation (currently, International Cooperation Directorate, Federal Ministry of Agriculture and Natural Resources), Ministry of Agriculture, Animal Resources and Irrigation (currently, Ministry of Production and Economic Resources), River Nile State, Ad-Damir city, and IMOs of Aliab and Kitiab.
Other partner countries cooperating organizations, etc.		(None in particular)
Cooperating organizations in Japan		NTC International Corporation
Related projects		Grant Aid Project: "Project for Upgrading Food Production Infrastructure in the Republic of Sudan" (October 2012)

1.3 Terminal Evaluation Summary

The following is a summary of the projects' terminal evaluation, as described in the Project Completion Report.

Over the course of the four-year project period, the project team worked with the relevant departments of the Ministry of Production, River Nile State (currently, Ministry of Production and Economic Resources, River Nile State; hereinafter referred to as "MoPER-RNS"), the main C/P agency, as well as with the staff of the IMOs in the target schemes. As a result, the four outputs listed above, as well as the project purpose, were met.

Since farmers are highly motivated to cultivate citrus fruits and planting areas are also on the rise, it was predicted that the achievement of the overall goal, "Agricultural production in the target irrigation schemes is increased" could be successfully achieved by continuing to apply "appropriate irrigation farming." In order to achieve this goal, it is very important to ensure that

the action plan for the dissemination of the model techniques¹ is implemented for its sustainability after the completion of the project. It is also necessary for the state government to continue to provide necessary support and follow-up to IMOs, besides IMOs play a key role in proactively implementing the irrigation scheme management.

1.3.1 Project Purpose Achievement Status at Project Completion

At the project's completion, it was judged to have largely achieved the project purpose since the target values for the three indicators listed below were mostly achieved.

(1) Implementation rate of annual plan for maintenance of irrigation facilities, (2) Implementation of quantitative water distribution management at irrigation water diversion facilities by IMOs, and (3) Introduction of improved farming techniques and their implementation by farmer groups.

1.3.2 Achievement of the Overall Goal at Project Completion (Including Other Impacts)

Compared to the beginning of the project, the citrus cultivation area increased by 86% in Aliab (achieving the target value of 23% increase). In Kitiab, although the newly developed planting area increased due to the high motivation of farmers to grow citrus trees, there was no change in cropping area due to a regulation that prevents adding areas of fruit trees that have not yet produced fruit within 5 years of planting to the total cropping area value. Cropping area was expected to increase steadily in the future as the saplings mature. In other words, there is a possibility that the overall goal will be achieved.

1.3.3 Recommendations at Project Completion

(1) Regarding citrus cultivation

The representative crop in the target areas was citrus, which has a high cash value, and the farmers' willingness to plant it was the highest. At the time, it was anticipated that citrus planting would continue to grow. To ensure the project's long-term viability, the reliable implementation of the action plan for disseminating the model technology that the Sudanese side has been carrying is extremely important for ensuring sustainability after the completion of the project. Therefore, it was recommended that the state government continue to provide necessary support and follow-up, in addition to implement IMOs' roles in proactively at the irrigation schemes.

(2) Challenges in promoting the widespread adoption model techniques

The following were the main challenges in promoting the widespread adoption of model techniques introduced in this project: (a) to promote the extension and development

¹ Operation and maintenance techniques for irrigation and improved farming techniques.

of adoption model techniques in the state, it is necessary to coordinate according to the conditions of each irrigation scheme, (b) it is necessary to promote capacity development of the state government and IMOs and have support from the Federal Ministry of Agriculture and Natural Resources for the development of irrigation facilities, as there are many schemes in River Nile State that have problems in maintaining their pumping facilities and irrigation water supply, (c) to introduce of oilseed crops (sesame and peanuts), it is necessary to develop small-scale processing facilities to add value and secure sales channels, (d) to encourage activities such as small-scale processing facilities and value chain development by farmers themselves, it will be necessary to disseminate and promote activities through the formation of farmer groups, rather than through individual farmers.

2. Survey Overview

2.1 External Evaluators

Isao Dojun, Takuya Itoh², Tatsuro Yokawa (Chuo Kaihatsu Corporation)

2.2 Survey Period

The study was conducted in the manner described below for the ex-post evaluation.

Survey Period: November 2020 to March 2022

Field survey: May 2021 to September 2021 (field survey conducted by field survey assistants)

2.3 Evaluation Constraints

The implementing agency at the Sudanese federal government level for both projects was the International Cooperation Directorate, Federal Ministry of Agriculture and Natural Resources. However, the information provided by this organization was primarily policy-related, with no specific information on the Grant Aid Project or the Technical Cooperation Project obtained. This imposed a minor constraint on the judgment process in relation to the five evaluation criteria. Furthermore, factors such as Sudan's political instability, Ramadan, and COVID-19 hampered the efficiency of our inspection visits to the project areas, interviews with relevant people, and information gathering.

In terms of project evaluation, the Technical Cooperation Project ended in November 2019, and the core period for the ex-post evaluation was 2021. Because an ex-post evaluation of technical cooperation projects normally assesses the situation three years after project completion, it should be noted that the evaluation occurred less than three years after the project's completion.

² Assisted by: Remote Sensing Technology Center of Japan

3. Evaluation result (Rating: A)³

3.1 Relevance (Rating: ③)⁴

3.1.1 Consistency with development policies

1) The main objectives of EPAR (2008) were to improve food security and agricultural productivity, promote the export of agricultural and livestock products, reduce poverty, boost incomes, and to restore and conserve natural resources. To achieve these objectives, the plan focused on developing agriculture-related infrastructure (irrigation and distribution/logistic systems), improving water resource management capacity, improving farming techniques and their agricultural extension systems, enhancing research functions, and promoting livestock farming and aquaculture. Both projects were implemented to upgrade irrigation facilities and equipment, ensure stable agricultural water supply, improve facility operation and maintenance capacity, and implement appropriate irrigated agriculture practices. Therefore, the project is highly consistent with the above-mentioned plan, which focuses on irrigation infrastructure development, improvement of water resource management capacity, and improvement of farmers' farming techniques.

2) In 2009, the Federal Ministry of Agriculture and Forestry (at that time) has launched preparation of *the "National Wheat Production Project"* which aims to upgrade irrigation facilities, increase wheat production, and achieve wheat self-sufficiency in order to ensure food security. Since both projects were implemented with the aim of upgrading irrigation facilities and equipment, promoting appropriate irrigated agriculture, and boosting agricultural production, they are consistent with the aforementioned policies, which include the development of irrigation facilities, the realization of appropriate irrigated agriculture, and the increase of agricultural production.

3) The strategic objectives of *the National Development Strategy⁵ (2017-2020)* in the areas of production and productivity include agricultural revival, ensuring food security, and optimizing the use of the Nile River, Red Sea and groundwater. Thus, increasing agricultural production and ensuring food security continue to be important. Both projects aimed to increase food production by upgrading irrigation facilities and equipment and promoting appropriate irrigated agriculture practices that use the Nile as a water source. Based on this, both projects are deemed consistent with the policies mentioned above, which aim to ensure food security and optimize the use of the Nile, Red Sea, and groundwater.

³ A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory

⁴ ③: High, ②: Moderate, ①: Low

⁵ National Strategic Development Plan (2017-2020) (prepared by the National Council for Strategic Planning). As material on this policy was obtained, it has been described based on the policy's content.

3.1.2 Consistency with Development Needs

During the planning stage, it was discovered that, while irrigation was necessary for stable agricultural production due to the low annual rainfall in the project target areas, there were issues such as deterioration of previously installed irrigation facilities (pumping facilities, etc.) and insufficient maintenance of irrigation canals. There was also a need to strengthen the capacity of organizations responsible for operation and maintenance of irrigation facilities, as well as to introduce improved farming techniques at the farmer level.

In its *National Development Strategy (2017-2020)* at the time of the ex-post evaluation, the Sudanese government continues to prioritize agricultural production and food security, including agricultural revival, food security, and optimizing the use of the Nile, Red Sea, and groundwater. The River Nile State government also emphasizes the operation and maintenance of irrigation facilities, specifically pump station maintenance, weeding and sediment removal of main and secondary irrigation canals, and the operation and maintenance (O&M) of water control equipment, in order to respond to population growth, reduce poverty, and improve living standards. There are still development needs to address these issues because there are many irrigation schemes in Sudan where irrigation facilities have deteriorated, and because there are not enough staff with the given maintenance budget and management capacity for irrigation facilities.

Summarizing the preceding points, it is reasonable to conclude that, at the time of ex-ante and ex-post evaluation, both projects are highly consistent with needs relating to the development of irrigation facilities and the strengthening of irrigation facility O&M.

3.1.3 Consistency with Japan's ODA Policy

According to the Ministry of Foreign Affairs' Japan ODA Data Book (2012 edition) at the time of planning the Grant Aid Project, one of the priority areas for ODA to Sudan is "agricultural development" and "The country has a high potential for agricultural development. On the other hand, given that many of Sudan's impoverished citizens is greatly engaged in agriculture, Japan will support the development of the agricultural sector, which is expected to contribute to poverty reduction and food security in Sudan." At the time of the Technical Cooperation Project's planning, the 2014 Japan ODA Data Book maintained the same policies, with "agricultural development" listed as a priority area. Because both projects are agricultural development-related and are expected to contribute to food security, they were highly consistent with Japan's ODA policy at the time of planning.

Based on the above, the implementation of both projects is highly relevant as it is highly

consistent with Sudan's development policy, development needs, and Japan's ODA policy.

3.2 Efficiency (Rating: ③)

3.2.1 Outputs

(1) Grant Aid Project

As shown in the table below, the Grant Aid Project improved irrigation facilities in the project's three target irrigation areas (Aliab and Kitiab in River Nile State, and the K14 area of New Halfa in Kassala State) by upgrading pumping equipment and constructing pump stations, as well as strengthening the management capacity of IMOs. The project also included technical guidance for the detailed design, construction supervision, and procurement management. In addition, the Sudan side carried out excavation and repairs of existing irrigation canals.

Table 1 Project Scope of the Grant Aid Project (Planned and Actual)

	Planned	Actual
Equipment	Power pump equipment upgrades · Aliab: 1.0 m ³ /s x 12.0 m x 4 units · Kitiab: 1.0 m ³ /s x 11.4 m x 4 units · New Halfa K14: 3.5 m ³ /s x 9.6 m x 3 units	Power pump equipment upgrades · Aliab: 1.0 m ³ /s x 12.0 m x 4 units · Kitiab: 1.0 m ³ /s x 11.4 m x 4 units · New Halfa K14: 3.5 m ³ /s x 9.6 m x 3 units
Civil engineering	[Work covered by the Japan side] Pump station building construction (upgrade) (Aliab and Kitiab) [Work covered by the Sudan side] · Aliab and Kitiab: Excavation and repair of irrigation canals, transformer installation, gate repair, etc. · New Halfa K14: Customs clearance, inland transportation, installation, etc. of pump equipment	[Work covered by the Japan side] Pump station building construction (upgrade) (Aliab and Kitiab) [Work covered by the Sudan side] · Aliab and Kitiab: Secure and clear the land for construction of pump station, secure temporary yard for construction, install transformer (1,500 kVA), construct spare parts stockyard (the above works have been completed: at the time of defect inspection), excavate and repair the irrigation canals (in progress at the time of defect inspection), repair gates and crossing bridge (in progress in Kitiab, not started in Aliab at the time of defect inspection) · New Halfa K14: Excavation and repair of irrigation canals (completed), customs clearance, inland transportation, installation, etc. of pump equipment (completed)
Soft Component	· Strengthen the management capacity of IMOs · Strengthen the ability to maintain irrigation facilities	· Strengthen the management capacity of IMOs · Strengthen the ability to maintain irrigation facilities

Source: Materials provided by JICA, Cooperative preparatory survey reports

(2) Technical Cooperation Project

The table below shows the Technical Cooperation Project's implementation periods and cooperation amounts, as well as contributions from both the Japan and Sudan sides.

Table 2 Project Scope of the Technical Cooperation Project (Planned and Actual)

	Planned	Actual
Cooperation amount and period	(1) Collaboration amount: 420 million yen (excluding expenses for the detailed planning survey) (2) Cooperation period: Planned for October 2015–October 2019 (48 months)	(1) Collaboration amount: 423 million yen (excluding expenses for the detailed planning survey) (2) Cooperation period: November 2015–November 2019 (48 months)
Japan side inputs	1. Dispatch of experts: Long-term and short-term experts (Technical fields include general/irrigation management, irrigation facility O&M, water management, farming/farmer organizations, work coordination/training, etc.) 2. Acceptance of trainees: (acceptance of trainees from IMO, etc. (Japan/third country)) 3. Third country training: 4. Equipment provision: (vehicles, office equipment) 5. Overseas activities cost:	1. Dispatch of experts: 6 people (6 people in 5 fields) 0 Long-term experts; 6 Short-term experts, (shuttle type dispatch) (Technical fields: 1 person in general/irrigation management, assistant general management/irrigation management/irrigation facility O&M/water management, farming/farmer organizations, cultivation/training management; 2 persons in work coordination/training) 2. Accepted trainees: 0 3. Third country training: 13 (Egypt) 4. Equipment provision: 7.8 million yen (computers, UPS, motorcycle, water-saving irrigation equipment, hand tractor, oil squeezer, peanut peeler, refrigerated storage equipment, etc.) 5. Overseas activities cost:
Sudan side inputs	<ul style="list-style-type: none"> • Counterparts and their associated costs • Costs associated with office space, office equipment, and their maintenance • Budget for counterpart travel and transportation expenses, equipment transport expenses, etc. 	<ul style="list-style-type: none"> • Counterparts and their associated costs (actual value unknown) • Costs associated with office space, office equipment, and their maintenance (actual value unknown) • Budget for counterpart travel and transportation expenses, equipment transport expenses, etc. (actual value unknown)

Source: Ex-ante Evaluation Paper, Project Completion Report, and materials provided by JICA

3.2.2 Inputs

3.2.2.1 Project Costs

(1) Grant Aid Project Implementation Costs

On the Japan side, the project was budgeted at 3.045 billion yen, but the actual cost was 2.829 billion yen, which was within the plan (216 million yen decreased, or 92.9% of the plan). The primary reason for the cost reduction on the Japan side was that, of the approximately 300 million yen reserve fund, only about 20 million yen was actually used (costs related to design changes). There was no information available on the (actual) project costs borne by the Sudanese side.

(2) Technical Cooperation Project Implementation Costs

In comparison to the 420 million yen planned cooperation amount from Japan at the time of planning, the actual amount was 423 million yen, which was slightly higher than the planned amount (100.7%).

3.2.2.2 Project Period

(1) Grant Aid Project Implementation Period

The planned implementation period was 41 months (October 2012-February 2016) and the actual implementation period was 38 months (October 2012-November 2015). In comparing with the planned period, the actual period was within the plan (92.7% of the plan). The primary factor that contributed to the project's timeline reduction was increased efficiency in the concrete laying process (specifically, due to daytime temperatures exceeding 40°C at the project site, work was performed at night to maximize efficiency).

(2) Technical Cooperation Project Implementation Period

The plan was 48 months (October 2015-October 2019). Actual implementation time matched the originally planned 48 months (November 2015-November 2019), following the original plan (100.0%).

3.2.2.3 Integrated Evaluation of Both Projects

The Grant Aid Project was implemented at 92.7% of the planned duration, while the Technical Cooperation Project was implemented at 100% of the planned duration. Based on averaging both projects, the implementation period was 96.4% of the plan. In addition, the project cost of the Grant Aid Project was 93.0% of the plan, while the project cost of the Technical Cooperation Project was 100.7% of the plan. When both projects are combined, the average project cost ratio is 96.9%.

From the above, when both projects are evaluated in an integrated manner, both the project cost and project period were within the plan. Therefore, efficiency of the project is high.

3.3 Effectiveness/Impact (Rating: ③)⁶

3.3.1 Effectiveness

3.3.1.1 Quantitative Effects

(1) Quantitative Effects of the Grant Aid Project

The expected effect of the project was to contribute to agricultural development in Kassala and River Nile states by achieving a stable supply of agricultural water and reducing the burden of facility maintenance. The table below shows the achievement status of quantitative indicators that express the effectiveness of this project. The objective of the project is to contribute to agricultural development in the above-mentioned states by achieving a stable supply of agricultural water and reducing the burden of facility maintenance, and the

⁶ Effectiveness evaluations take project impacts into account when determining ratings.

qualitative indicator for the project is "Food costs in River Nile and Kassala states will reduce as a result of the region's increased food production." Since the project has been requested by the Sudanese government to the government of Japan in the expectation that the *"Executive Programme for Agricultural Revival"* and the *"National Wheat Production Project"* will be promoted, an indicator "3) wheat unit yield kg/feddan" is set at the time of the ex-post evaluation as an additional indicator. In determining the quantitative effect on Effectiveness, the three indicators are comprehensively considered.

Table 3 Achievement Status of Quantitative Effectiveness Indicators

	Baseline	Target	Actual		
	2011	2018	2018	2019	2020
		3 years after project completion	3 years after project completion	4 years after project completion	5 years after project completion
(1) Irrigated farmland area (ha) without water shortages during peak demand season (Note 7)	0	9,471 (Note 1)	12,325 (130.1%)	12,390 (130.8%)	13,150 (138.8%)
(2) Cost required to maintain irrigation facilities (in 1,000 SDGs)	11,004	10,569	(1) n.a. (2) 3,382 (3) 3,220	(1) n.a. (2) 3,558 (3) 4,920	(1) n.a. (2) 7,718 (3) 10,730
(3) Unit yield of wheat in kg/feddan (average of 3 irrigation schemes) (2011 figure was 867 kg/feddan)	---	---	n.a. (1,000 kg/feddan) (Note 6)	n.a. (1,200 kg /feddan) (Note 6)	1,080 kg/feddan (Avg. of 3 areas)

Note 1: Area calculated based on irrigation plan-related data contained in Preparatory Survey Report. The value of areas is different with the target values listed in the ex-ante evaluation paper. The target value in ex-ante evaluation paper is the total value of the irrigated area of the three irrigation schemes. Since the crop cultivation seasons are different by crop and there is fallow land, it is not irrigated at all the agricultural land in the scheme at the same time. Since the preparatory survey report describes the season when irrigation water is most needed and the planned irrigation area at that time, based on the planned irrigation area, "the irrigated farmland area without water shortage during peak water demand season" was calculated.

Note 2: Numbers in parentheses are compared to the target data.

Note 3: SDG is the abbreviation for the Sudanese pound, the country's official currency.

Note 4: (1) is Aliab, (2) is Kitiab, (3) is New Halfa K14 area; n.a. means "data not available".

Note 5: 1 feddan is 0.42 ha.

Note 6: Average of Aliab and Kitiab areas.

Source: Prepared based on materials provided by JICA, information provided by the implementing agency, etc.

Note 7: Area was calculated by analyzing satellite images.

For "Irrigated farmland area (ha) without water shortage during peak demand season," values were compared for the period of highest irrigation water demand for the irrigation plans described in the preparatory survey report, between the planned irrigated area for that period and the area judged to be free of water shortage (farmland area with good crop color) based on satellite image analysis⁷. The results of the analysis indicated that water was being

⁷ Using satellite images (from Sentinel-2) taken on cloudless days of the month with the highest monthly irrigation requirement, the irrigated farmland area determined to not be experiencing water shortage was calculated (calculated by setting vegetation index and boundary conditions (i.e. the land area of dark green areas was calculated)).

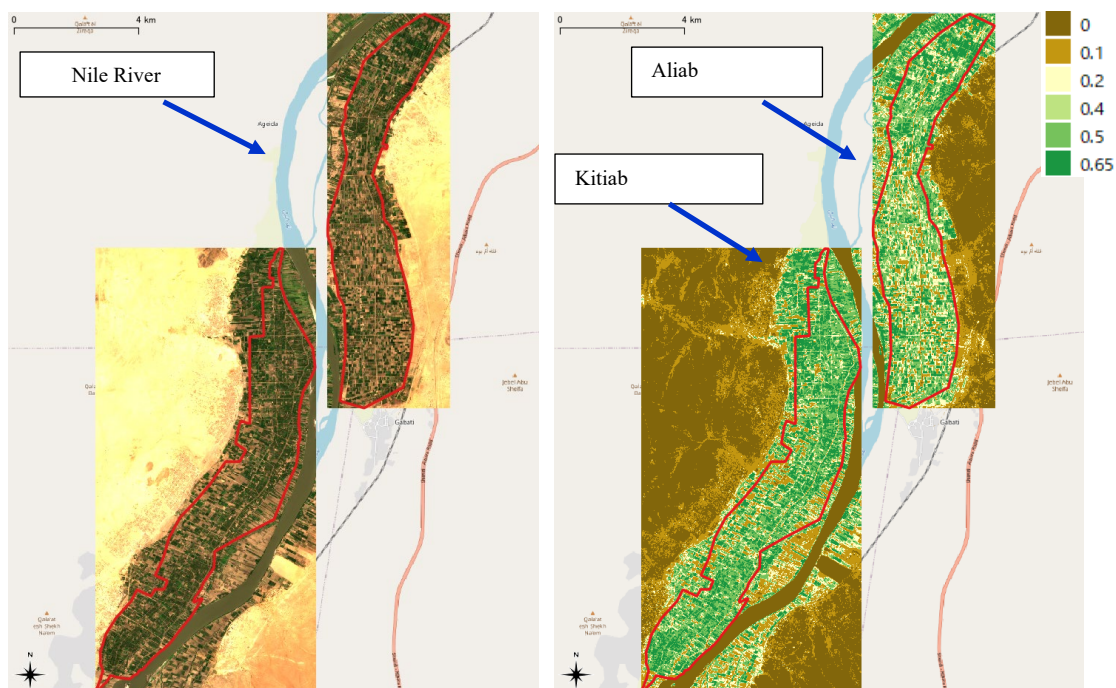
supplied to more farmland than the planned irrigated area. This demonstrates that the development of irrigation facilities has resulted in a more stable water supply.

The next section provides an overview of the approach used to estimate the area of irrigated farmland not experiencing water shortages using satellite imagery.

Aliab, Kitiab, and New Halfa K14, which are irrigation areas to be analyzed, are all in an arid region with annual rainfall ranging from 50 to 250 mm. Crops cannot thrive in this climate without irrigation. Therefore, we can assume that the irrigated areas where vegetation can be seen in satellite image analysis are properly irrigated and there is no water shortage in these farmlands. As a result, satellite imaging (optical imaging from the "Sentinel-2" satellite) was used to detect and assess vegetation in irrigated areas by selecting cloud-free days⁸ during the months when irrigation water is most needed (January for Aliab and Kitiab areas and September for New Halfa K14 area). To detect vegetation in satellite images, the Normalized Difference Vegetation Index (NDVI) method was used. If the NDVI was above a certain threshold, specifically 0.35, the area was considered to have good "vegetation" (no water shortage). By reading the satellite images visually, the area without water shortages was estimated for each of the three areas. The total values are listed in the column "(1) Irrigated farmland area (ha) without water shortage during peak demand season" of Table 3.

For reference, the figure below shows satellite images (left side) and NDVI images (right side) of Aliab and Kitiab areas (the part outlined in red is the boundary of the target area).

⁸ The satellite images used for Aliab and Kitiab were taken on January 23, 2018, January 23, 2019, and January 28, 2020. The dates for New Halfa K14 were September 27, 2018, September 12, 2019, and October 11, 2020. (October was used due to no cloud-free days in September.)



Note: Values in the upper right corner of the figure are the NDVI thresholds.

The data for "Cost necessary to maintain irrigation facilities (1000 SDGs)" could not be collected for one of the three areas. As this made it difficult to compare the data against target values, the project achievement level cannot be evaluated. Even if the data had been available, it would have been difficult to compare the data accurately due to the significant impact of Sudan's recent inflation rate increase.

Although no target year or target value was set for the unit yield of wheat (kg/feddan, the average of three irrigation schemes), it increased by around 25% to 1,080 kg/feddan in 2020 compared to the yield level of 867 kg/feddan in 2011 before the two projects were implemented. Therefore, it can be said that there was an effect of the two projects.

3.3.1.2 Qualitative Effects (Other Effects)

(1) Qualitative Effects of the Grant Aid Project

One of the indicators to express the qualitative effects of the project was "Food costs in River Nile and Kassala states will reduce as a result of the region's increased food production". Wheat, as a staple food in Sudan, can be considered a representative food for judging food prices. However, assessing the level of achievement of this indicator was impossible because the country relies on imports for roughly 50%⁹ of its domestic wheat consumption (in the

⁹ Bumper Harvests and Record Wheat Production Propelling Sudan Towards Wheat Self-sufficiency, WORKING PAPER 2020/001, ICARDA

2019/2020 growing year). Wheat prices are heavily influenced by the exchange rate, and wheat production in the project area has only a minor impact on wheat prices.

As an alternative way to assess qualitative effects, farmers were interviewed¹⁰ to discover (1) farmers' satisfaction with irrigation water supply and (2) farmers' satisfaction with irrigation water delivery times. The evaluation results are shown below (Tables 4 and 5).

Table 4 (1) Farmers' level of satisfaction with irrigation water supply (in %)

Irrigated area	Very satisfied	Satisfied	Somewhat dissatisfied	Very dissatisfied
Aliab	73.3	23.3	3.3	0.0
Kitiab	67.7	6.5	25.8	0.0
New Halfa K14	20.0	23.3	20.0	36.7
Avg.	53.7	17.7	16.4	12.2

As shown in Table 4, Aliab residents were very satisfied with the amount of irrigation water provided (96.7%, including both "very satisfied" and "satisfied"). When combining "very satisfied" and "satisfied," Kitiab had a relatively high satisfaction level (74.2%), while the percentage of "somewhat dissatisfied" was higher at 25.8%. The combined percentage of "very satisfied" and "satisfied" drops to 43.3% for New Halfa K14, while the percentage of "very dissatisfied" rises to 36.7%. In Aliab and Kitiab, as a result of the synergistic effect of supports to improve the operation and maintenance capacity of irrigation facilities through the Technical Cooperation Project, it led to the expansion of the irrigation water supply coverage area and the optimization of the irrigation water supply timing. Because of these, the degrees of satisfaction at Aliab and Kitiab become higher than New Halfa K14. Nevertheless, the average of "very satisfied" and "satisfied" responses in the three areas was 71.4%, which is regarded as achieving a moderate satisfaction level.

Any lack of irrigation canal maintenance (weeding and removal of sediment in canals) will lead to insufficient water quantity, especially toward the terminus end of the canals. Farmers' interviews conducted by field survey staff revealed a deficiency in irrigation canal maintenance, particularly in Kitiab and New Halfa. Farmers on the canal's downstream end, in particular, expressed dissatisfaction, and we confirmed that this was due to a lack of canal maintenance. In addition, in the case of New Halfa K14 area, there was also a relatively high percentage of farmers on the upstream end of the canal who were not satisfied (compared to other areas). Along with irrigation canal maintenance, frequent power outages (caused by pump station shutdowns) occasionally harmed irrigation water supply. The presence of seed production companies' farm plots, which require significant irrigation water, could also have

¹⁰ Interviews were conducted with 30 farmers in each area. Irrigation areas were divided into three categories based on distance from the pump station: Upstream, midstream, and downstream of the irrigation canal, with ten farmers interviewed in each.

been a factor.

Table 5: (2) Farmers' Satisfaction with Irrigation Water Delivery Times (in %)

Area	Very satisfied	Satisfied	Somewhat dissatisfied	Very dissatisfied
Aliab	70.0	26.7	3.3	0.0
Kitiab	64.5	9.7	25.8	0.0
New Halfa K14	23.3	13.3	30.0	33.3
Avg.	52.6	16.6	19.7	11.1

As shown in Table 5, the level of satisfaction with water delivery times was comparable to the level of satisfaction with irrigation water amounts. The level of satisfaction in Aliab was extremely high (96.7% including both "very satisfied" and "satisfied"). When combining "very satisfied" and "satisfied," Kitiab had a relatively high satisfaction level (74.2%), while the percentage of "somewhat dissatisfied" was higher at 25.8%. For New Halfa K14, the combined percentage of "very satisfied" and "satisfied" drops to 36.6%, and the percentage of "very dissatisfied" increases to 33.3%. The average of all three areas is 69.2%, which includes both "very satisfied" and "satisfied," indicating that a certain level of satisfaction has been achieved. As previously stated, frequent power outages are one of the major problems in the case of New Halfa K14, and inadequate canal maintenance (weeding along the canal, removal of sediment in the canal, etc.) is also considered a problem in supplying an adequate amount of irrigation water when it is needed.

Among the quantitative effects, the area of irrigated farmland that did not experience water shortages during peak demand season exceeded the target. The project's effect was evident as the unit yield of wheat increased. Due to a lack of data, it was impossible to determine whether the project was successful in lowering irrigation facility maintenance costs. In terms of the project's qualitative effects, the average level of farmer satisfaction with irrigation water supply and timing of delivery in the three areas was generally consistent, indicating that the project was effective. That being said, satisfaction was low in some areas. The lack of weeding and sediment removal in the canals is a problem for supplying enough irrigation water when it is needed.

3.3.1.3 Achievement Status of Technical Cooperation Project Objectives

The following four items were set as objectives of the Technical Cooperation Project: (1) Institutional capacities of IMOs are enhanced to manage the irrigation system; (2) Capacities of IMOs are improved to conduct appropriate operation and maintenance (O&M) of irrigation facilities; (3) Effective measures are developed to improve water distribution; and (4) Effective methods are developed as a model for improved farming techniques. The

Project Completion Report (November 2019) determined that (1) was achieved, and (2), (3), and (4) were mostly achieved. The project purpose "Appropriate irrigated agriculture is practiced in the target irrigation schemes" is judged to have been largely achieved. The table below shows the results and achievement level (at project completion) for each indicator for the project purpose.

Table 6 Project Purpose Achievement Level

Purpose	Indicator	Actual
Project purpose: Improved irrigated agriculture is practiced in the target irrigation schemes	(1) At least 80% of the activities in the annual plan for irrigation facility maintenance are carried out.	Annual plans for operation and maintenance of irrigation facilities have been prepared by the target two IMOs and almost all planned activities are implemented.
	(2) Quantitative water distribution management is implemented at major irrigation facilities under the management of the irrigation scheme organization.	Quantitative water diversion and management at major diversion facilities can be carried out by scheme personnel (gatekeepers and inspectors) under management of the target two IMOs.
	(3) The improved farming techniques introduced by the project will be practiced by at least five trained farmer groups.	Farmers' and women's groups have been trained as good candidates for growers' associations, and eight groups have implemented the improved farming-related techniques (model techniques) introduced by the project.

3.3.2 Impacts

3.3.2.1 Intended Impacts

(1) About the Grant Aid Project

An indicator of the impact of the Grant Aid Project was whether it "contributes to the agricultural development in both states." Thus, under the assumption that a stabilized water supply would also increase the cropping area of onions and legumes (fava bean), the evaluation was based on whether the cropping area (acreage) of these crops had increased or not.

1) Onion cropping area

The IMO in Aliab provided information on the onion cropping area. The area under cultivation increased significantly from 100 feddans (42 ha) in 2009/2010 to 712 feddans (299 ha) on average in 2018-2020. In Aliab, it is judged that the upgrading of irrigation facilities by both projects had a positive impact on the stabilizing irrigation water and improving irrigation management techniques.

2) Legumes (fava bean) cropping area

The IMO in Aliab also provided data on the legumes cropping area. In Aliab, the average

fava bean cropping area decreased from 620 feddans (260 ha) in 2009/2010 to 487 feddans (205 ha) in 2018-2020. As described later in this document, we infer that this was due to the citrus cropping area in Aliab doubling from 1,077 feddan (452 ha) in 2015 to 2,200 feddan (924 ha) in 2020. As a result, it is judged that there was no impact on legume cultivation. On the other hand, the implementation of both projects resulted in a consistent supply of irrigation water, which is judged to have had a positive effect on increasing the cropping area of citruses, which are easily convertible to cash.

(2) About the Technical Cooperation Project

We investigated the achievement status of the project's overall goal and other impacts.

1) Achievement Status of the Project's Overall Goal

The overall goal of the project was that "Agricultural production in the target irrigation schemes is increased," accompanied by a performance indicator of "Production of citruses is increased by 23% in Aliab and 26% in Kitiab by 2022 compared to the production in the beginning of the Project." The table below summarizes the actual results obtained during the ex-post evaluation process. Because the project began in November 2015, 2015 figures are used as the baseline.

Table 7 Achievement Level of the Project's Overall Goal

Area	Item	2015	2019	2020
Aliab	Cropping area (in feddans)	1,077	2,006 (86% increase)	2,200 (104% increase)
	Production volume (in tons)	n.a.	10,770	20,000
Kitiab	Cropping area (in feddans)	2,060	2,060 (0% increase)	3,000 (46% increase)
	Production volume (in tons)	n.a.	20,600	25,000

Note: Figures in parentheses are compared to 2015.

Source: Questionnaire survey results, interview survey results, and data from MoPER-RNS.

In Aliab, the citrus cropping area increased by 104% (almost doubled) from 1,077 feddans (452 ha) in 2015 to 2,200 feddans (924 ha) in 2020. Although there were no available production figures for 2015, production of 10,770 tons in 2019 nearly doubled to 20,000 tons in 2020. Therefore, the target of increasing production by 23% by 2022 is judged to have already been achieved by 2020.

Cropping area in Kitiab increased by 46% from 2,060 feddans (865 ha) in 2015 to 3,000 feddans (1,260 ha) in 2020. Production increased by around 21% from 20,600 tons in 2019 to 25,000 tons in 2020. Although production data for 2015 was not available, cropping area increased by 46% from 2015 to 2020. Therefore, it is estimated that the target of 26%

increase in production has already been achieved in Kitiab.

Based on these data, the Technical Cooperation Project can be judged to have had a significant impact on increasing citrus fruit production, one of the representative agricultural products in both districts, as a result of the promotion of appropriate irrigated agriculture.

2) Maintaining and Expanding the Technical Cooperation Project's Results

As described in the section "Achievement Status of Technical Cooperation Project Objectives," four outcomes were set, and at project conclusion, one of the four was achieved, while the other three were largely achieved. The items for which the results of the cooperation were maintained or expanded at the time of the ex-post evaluation were listed for each set outcome (including some items that were not utilized).

a) Output 1: "Institutional capacities of IMOs are enhanced to manage the irrigation system"

Both the Aliab and Kitiab IMOs continue to properly record and maintain their accounting books and records. Both IMOs also have liaison and coordination systems in place with relevant organizations, such as the River Nile State government.

b) Output 2: "Capacities of IMOs are improved to conduct appropriate operation and maintenance (O&M) of irrigation facilities"

Each year, the Aliab Irrigation Scheme Management Body develops a facilities maintenance plan and implementation rate of the plan is high as 90% to 95%. To some extent, the Kitiab Irrigation Scheme Management Body has also been developing plans annually and its implementation rate is slightly lower as 80% to 85%.

c) Output 3: "Effective measures are developed to improve water distribution"

Water distribution management plans are being prepared annually by both IMOs. Although several textbooks and manuals were developed during the project period, some were used by both IMOs while others were not. Manuals are also used to some extent by MoPER-RNS. For example, it has used them to create maps for the state's two irrigation schemes (Fadlab and Muslamab). In terms of technology use in other irrigation areas throughout the state, MoPER-RNS has used the following technologies:

1. Water distribution technology was utilized in three irrigation schemes (Zeidab, Fadlab, and Medeni).
2. Technology to prevent water leakage from irrigation canals was utilized in two irrigation schemes (Zeidab and Medeni).
3. Irrigation canal shaping technology (to adjust the shape of the irrigation canal)

was utilized in two irrigation schemes (Zeidab and Fadlab).

4. Methods that use herbicides as an irrigation canal weed-management method were utilized in two irrigation schemes (Zeidab and Fadlab).

d) Output 4: "Effective methods are developed as a model for improved farming techniques"

Water-saving irrigation methods have made little progress in terms of introduction and adoption by farmers. Further, neither irrigation scheme has developed any new demonstration tests related to post-harvest treatment of fruit trees or vegetables, or the processing of oil crops. Textbooks/manuals on farm improvement have been used by some farmers during the project period. Among activities related to farming improvement (agricultural product processing), the introduction of oil crop cultivation was promoted in other irrigated areas (Matama, Damer, Zeidab, Hasa). In Aliab, farmers from other irrigation schemes (Zeidab and Soula) have brought onions and other crops to use the dryers installed with the support of this project.

As mentioned above, activities necessary to maintain the outcome of "Improved irrigated agriculture is practiced in the target irrigation schemes," which is the project's purpose, have been implemented continuously. These include maintaining a liaison/coordination system with the IMO and state government; preparing and implementing the accounting work and maintenance plans for irrigation facilities; preparing water distribution plans in each year; and disseminating water distribution management and irrigation canal maintenance techniques to other irrigation schemes in River Nile. Based on this, we can conclude that the output sustainability has been maintained to a certain degree.

The items listed below are examples of cooperation outputs (project objective) that have been maintained or expanded even after ex-post evaluation. Items are organized by indicator (and include points not implemented).

- Irrigation Facilities O&M Plans are being prepared every year and implemented according to the plan. In 2019 and 2020, the implementation rate was at least 80% (based on the IMOs data obtained through hearing), which we consider to be satisfactory.

Table 8 Implementation Rate of Irrigation Facilities O&M Plans

Irrigated area	2019 implementation rate	2020 implementation rate
Aliab	90%	95%
Kitiab	80%	85%

Source: Information on IMOs in Aliab and Kitiab

- In both irrigation schemes, annual water distribution plans are being developed and implemented. In Aliab, irrigation canal and control facility O&M is being performed continuously and appropriately, as is weeding and sediment removal from irrigation canals. Appropriate water distribution is also being implemented in Kitiab. However, power outages (which cause pumping and water supply stops), Nile water level drops (which makes water pumping difficult), and weed overgrowth in irrigation canals have all hampered the implementation of water distribution plans.
- Of the eight farmer/women's groups trained, only one is currently engaged in activities related to vegetable drying. Some of the other groups have farmers who continue their activities on an individual basis. Some of the factors contributing to the lack of continuity include difficulties obtaining high-quality seeds, securing a market to sell vegetable seedlings, the impact of floods, insufficient farming funds, and a lack of state government support. It should be noted that no new farming groups have been formed since the Technical Cooperation Project's completion.

As previously stated, Irrigation Facilities O&M Plans, which are critical for maintaining project outcomes, are prepared and implemented on an annual basis, as are Water Distribution Plans. Based on this, we can conclude that the output sustainability has been maintained to a certain degree.

3.3.2.2 Other Positive and Negative Impacts

The following points were recognized as additional impacts of both projects.

(1) Environmental and social considerations

In terms of environmental and social considerations at the time of the ex-ante evaluation because the Grant Aid Project does not fall under the category of sensitive sectors/characteristics and sensitive areas, and negative impacts on the environment are judged to be insignificant, this category is judged as Category B. According to the ex-ante evaluation paper, this project did not require land acquisition or involuntary resident relocation, and no such activity has taken place. In order to prevent soil erosion from river embankments, the embankment slope protection method was changed from earth/gravel use to integrated sheet pile use, which is more effective in preventing erosion, and this method was implemented as better protection measure against soil erosion and high river flow velocity.. The implementing agency confirmed that no environmental issues related with noise, vibration, waste, and traffic safety arose during the construction period.

In the case of the Technical Cooperation Project, it was classified as Category C.

(2) Impact on women's groups and farmers

- The Onion Processing and Drying Group has continued its activities after the Technical Cooperation Project was completed. Not only members, but also women from surrounding villages have been cutting and (sunlight) drying large quantities of onions, and selling them by the bag in towns in the state. Based on this, we can conclude that the project had an impact on some of the women who participated and who continued to participate in the activities.
- When interviewing farmers to determine whether they are able to secure sufficient volume of their staple foods, they responded that they generally have sufficient food (although some farmers only produce citrus fruits). The majority of the respondents were either "very satisfied" or "satisfied" with their agricultural production and income (90% in Aliab and 87% in Kitiab area). Farmers in the two irrigated areas where both projects were implemented have generally been able to secure food.

(3) Collaboration with JICA's private sector partnerships (extension and demonstration projects)

River Nile State has a thriving onion farming industry and is Sudan's largest onion producer. As a result of the Technical Cooperation Project being implemented in this state, Japanese private company considered collaboration¹¹ with private sector partnership projects, and a demonstration project using electric dryers from Japanese private companies for onion drying is being implemented in River Nile State. The state government has installed an electric dryer in a cold storage facility in the state capital of Ad-Damir, and the onion drying project is being implemented in collaboration with the local growers' association. Training materials developed through the Technical Cooperation Project, specifically the "bookkeeping training" were used as-is in this extension and demonstration project to develop farming human resources. This is considered the ripple/synergistic effect of the Grant Aid Project and Technical Cooperation Project.

In terms of the quantitative and qualitative effects of the Grant Aid Project, it was possible to supply water during the peak demand period even beyond the planned irrigation area, wheat unit yield increased, and farmers were moderately satisfied with irrigation water supply and delivery times. As one of the project's impacts, a significant increase in onion cultivation area is confirmed.

¹¹ Since the Technical Cooperation Project included activities related to agricultural processing, they have been seeking collaborations.

An increase in citrus cropping area, the overall goal of the Technical Cooperation Project, has exceeded the target area. Some irrigation facilities O&M techniques, which were strengthened by the project, continued to be used. There is also a relatively high satisfaction level with farmers' agricultural production and income, and they are generally able to secure sufficient food.

This project has largely achieved its intended effectiveness, as evidenced by the examples above. As a result, the project's effectiveness and impact are high.

3.4 Sustainability (Rating: ②)

3.4.1 O&M Systems and Structures

Based on River Nile State agricultural scheme legislation, the irrigation areas in Aliab and Kitiab, which are located in River Nile State, are operated and maintained by IMOs in each area in financially independent systems. If an O&M budget is insufficient, support will be provided by the River Nile State Government and the Government of Sudan. Meanwhile, the New Halfa K14 is part of the New Halfa Irrigation Project area, a government-run project area. It is operated and maintained by New Halfa Agricultural Corporation, a government entity. For this reason, sustainability was individually evaluated for each the Aliab Irrigation Scheme Management Body, Kitiab Irrigation Scheme Management Body, MoPER-RNS, and New Halfa Irrigation Corporation.

(1) Aliab Irrigation Scheme Management Body

The table below shows the personnel structure before the implementation of the Grant Aid Project and at the time of the ex-post evaluation. (Note: Figures in parentheses are number of members)

Table 10 Personnel Structure Before and After the Implementation of the Grant Aid Project

Item	Before implementation	At the time of ex-post evaluation
Board (number of members)	11	22
Scheme staff (persons)	37	35
Irrigation & Agriculture Committee (persons)	4	5
Financial Committee (persons)	4	5
Pump operators (persons)	13	2
Canal & Farm Guards (persons)	7	9
Agricultural extensionists (persons)	2	2
Accountants (persons)	2	4

Source: Preparatory Survey and Aliab Irrigation Scheme Management Body

In the Preparatory Survey conducted prior to project implementation, the structure of the Aliab Irrigation Scheme Management Body was described as "relatively successful overall". There was no significant change in the number of personnel at the time of the ex-post evaluation, except that the number of pump operators decreased significantly while the number of board members increased significantly. Despite the decrease in pump operators, pump operation and maintenance are being carried out satisfactorily. According to an interview with the Aliab Irrigation Scheme Management Body, the organizational structure, responsibilities, accounting system, and staff number are adequate, but the capacity of approximately half of the staff is low and needs to be strengthened. Therefore, it is judged that the O&M system and structure of the Aliab Irrigation Scheme Management Body is generally satisfactory, although the capacity of staff needs to be further strengthened.

(2) Kitiab Irrigation Scheme Management Body

The table below shows the personnel structure before the implementation of the Grant Aid Project and at the time of the ex-post evaluation. (Note: Figures in parentheses are number of members)

Table 11 Personnel Structure Before and After the Implementation of the Grant Aid Project

Item	Before implementation	At the time of ex-post evaluation
Board (number of members)	11	Dissolved (18 members before dissolution)
Scheme staff (persons)	48	9
Irrigation & Agriculture Committee (persons)	None	Dissolved (5 members before dissolution)
Financial Committee (persons)	None	(Dissolved)
Pump operators (persons)	21	6
Canal & Farm Guards (persons)	2	12
Agricultural extensionists (persons)	1	0
Accountants (persons)	2	3

Source: Preparatory Survey and Kitiab Irrigation Scheme Management Body

The number of board members has increased, while the number of canal guards has increased significantly. In contrast, the number of staff has been dramatically reduced and the number of pump operators has declined. According to interviews, there is a particular shortage of electrical engineers in charge of pump stations, and there are challenges in dealing with pump breakdowns. According to the Preparatory Survey, "an increase in the number of canal & farm guards is deemed necessary to achieve efficient irrigation." In this regard, the implementation system for canal O&M has been strengthened since the number of guards was increased from two to twelve. However, it is difficult to evaluate the organizational and

personnel structure for O&M at the time of the ex-post evaluation, as the organizational structure appears to have been temporarily modified. Additionally, it is necessary to strengthen staff capacity and to assign a researcher to conduct a survey of the irrigation area's cultivation area, production volume, and crop productivity.

From the above, in terms of irrigation canal O&M, although the number of staff in charge has been increased and the implementation system has been strengthened, it is necessary to further strengthen the capacity including other staff. The organizational structure appeared to be undergoing temporary changes at the time of the ex-post evaluation, making it difficult to assess whether the organizational and personnel structure for O&M was appropriate at the time of the ex-post evaluation.

(3) New Halfa Irrigation Corporation

The New Halfa Irrigation Corporation under the Federal Ministry of Agriculture and Natural Resources is in charge of the operation and maintenance of the entire New Halfa Irrigation area, including K14 area of New Halfa.

Because data on the number of staff in charge of New Halfa K14 at the time of the ex-post evaluation was unavailable, it was not possible to determine whether an appropriate organizational and personnel structure for O&M is in place. However, based on the interview results, there appears to be a need to strengthen staff capacity in the following areas:

- In terms of the organizational and personnel structures, staff are assigned to handle the O&M of pump facilities and irrigation canals, as well as staff for managing the finances, O&M of irrigation facilities and administrative work are generally being performed efficiently (based on interviews by field survey staff).
- Irrigation canal sediment removal and weeding plans are being prepared by irrigation management staff.

Although only limited information could be obtained, it is judged that there is an effective O&M system and structure for New Halfa K14 area to some extent.

(4) Ministry of Production and Economic Resources, River Nile State (MoPER-RNS)

Although data on the number of employees were not available at the time of the ex-post evaluation, the Ministry had established the JICA Project Follow-up Unit during the implementation of the Technical Cooperation Project and provided the following support to the Aliab and Kitiab irrigation areas:

- Rehabilitation and periodic inspection of irrigation facilities (pumps, water flow controllers) and irrigation canal cleaning.
- Provision of agricultural extension services.

- Follow-up to both IMOs.

In fact, the state government funds irrigation facility maintenance, equipment procurement, and irrigation facility rehabilitation and new construction. In view of the above, the River Nile State Government is judged to have generally satisfactory organizational and staffing structures in terms of O&M support to irrigation areas.

(5) Summary of O&M Systems and Structures

Although there is a need to further strengthen the capacity of the staff of the IMOs in charge of the three irrigation areas, when considering the above points as a whole, the three IMOs have established fairly satisfactory O&M systems and structures. Additionally, MoPER-RNS has generally satisfactory organizational and personnel structures able to support the O&M of irrigation areas in the state.

3.4.2 Technical Aspects of O&M

(1) Application of Techniques Learned through the Grant Aid Project

The Grant Aid Project has strengthened the capacity of the staff of IMOs in the three areas on "irrigation related techniques" (through soft components). The table below shows whether IMOs continue to practice the irrigation-related techniques they were taught to strengthen their capacity (numbers indicate how many of the three areas are practicing the techniques).

Table 12 Status of Techniques in Regard to Continued Use

Technique	Number of areas practicing
(1) Methods for preparing and managing irrigation facility inventory table	3
(2) Methods for compiling pump operation records	3
(3) Methods for maintaining pumps learned during initial training	2
(4) Understanding irrigation-related laws and regulations	3
(5) Knowledge of wide-area water management	2
(6) Technique to calculate water volume with a computer	0
(7) Knowledge of equitable water distribution	3
(8) Technique for properly operating gates	2
(9) Understanding the annual O&M action plan	3
(10) Knowledge related to monitoring and feedback	2

Source: Interviews with IMOs in the three areas

Techniques 1, 2, 4, 7, and 9 are being practiced in all three areas. Techniques 3, 5, 8, and 10 are being practiced in two areas. No areas were practicing technique 6 on calculating water volume using a computer. Aside from using a computer to calculate water volume, the areas are generally continuing to apply the technologies they learned. Based on the results of the interviews with IMO staff, however, it is judged that there is a need to further strengthen the capacity of staff to help them properly utilize and practice the knowledge they learned, such

as calculating water volume with a computer.

The table below shows whether IMOs continue to practice the operations-related techniques they were taught to strengthen their capacity (numbers indicate how many of the three areas are practicing the techniques).

Table 13 Status of Techniques in Regard to Continued Use

Technique	Number of areas practicing
(1) Methods to organize and manage basic information about beneficiary farm households	3
(2) Methods to identify the needs of beneficiary farm households	2
(3) Use of water fee collection and management systems	3
(4) Formulation of annual action plans	3
(5) Holding of general and extraordinary meetings, etc. and taking of minutes	3
(6) Retention and recording of ledgers, vouchers and receipts	3
(7) Preparation of monthly financial reports	2.5
(8) Preparation and management of market price records for crops, fertilizers, etc.	1
(9) Capacity building manual for operating an IMO	1

Source: Interviews with IMOs in the three areas

With the exception of techniques 8 and 9, the implementation status is largely satisfactory, and the operating capacity of IMOs has been largely established.

(2) Application of Techniques Learned through the Technical Cooperation Project

- Regarding the action plan for promoting the widespread use of model techniques for the O&M of irrigation facilities, MoPER-RNS has been providing support to each IMO for the preparation of action plans, and an action plan has been prepared and put into practice in Aliab. Kitiab is also developing annual activity plans.
- With regard to introducing oilseed crops, there has been no dissemination to other farmers or formation of new farmer groups. In addition, the cultivation of oilseed crops is declining in Aliab. In Kitiab, the cropping area has decreased due to the circulation of poor quality sesame seeds. The introduction of sesame crops, which was one of the model techniques for improved farming practices, has been limited, and the same is true for oil extraction activities.
- As for the irrigation canal O&M, while IMOs continue to work, weeding has been insufficient, particularly in secondary canals. Weeding is insufficient in Kitiab, even in the main irrigation canal.

(3) Technical support from MoPER-RNS

The following technical support has been provided to the IMOs in Aliab and Kitiab:

- Electrical or mechanical engineers are being dispatched to pump stations when equipment in the pump stations malfunctions.
- Although not part of irrigation facility O&M, support is being provided in the form of disseminating farming techniques (farmer school type training), seed distribution (oil crops, vegetables, rice), and the provision of sowing equipment.
- In addition to providing moderate support for weeding/cleaning irrigation canals and rehabilitating flow control equipment, state government officials have visited pump stations to inspect their condition.

(4) Summary of the technical aspects of O&M

Some issues were observed among the techniques taught to IMO staff. These included failing to practice techniques for calculating water volume with a computer and failing to use some capacity building manuals on managing an IMO. Despite these issues, and the need to strengthen staff capacity, IMOs have achieved a moderate level of technical ability and are capable of operating and maintaining irrigation facilities. MoPER-RNS has also been providing technical support to the IMOs in Aliab and Kitiab. Taking these factors as a whole, it is judged that, to a certain degree, the three IMOs have achieved fairly satisfactory O&M skills.

3.4.3 Financial Aspects of Operation and Maintenance

(1) Aliab Irrigation Scheme Management Body

The table below shows the O&M budget amount for the Aliab Irrigation Scheme Management Body. The O&M budget in Sudanese currency (SDG) has increased in 2018, 2019, and 2020 (with a notable increase in 2020, however, inflation has risen in recent years). On the other hand, in dollar-equivalent terms, the budgeted amounts for 2019 and 2020 have decreased when compared to the budget for irrigation facilities O&M in 2018. While the IMO receives income from water fee collection and financial support from the state government, it seems that there is budget insufficiency because a lack of weeding in some canals has been observed. However, pump station O&M and a moderate level of irrigation canal O&M are being carried out. As such, financial sustainability is judged to have been achieved to a degree, although some issues persist.

Table 14 O&M Budget Amount for the Aliab Irrigation Scheme Management Body

Item	2018	2019	2020
Total O&M related budget (SDG)	4,748,723	5,953,190	9,270,015
Dollar-equivalent value	263,818	132,293	168,546
Water fee collection rate	69%	80%	79%

Source: Except for the dollar-equivalent values, all figures are based on interviews with the Aliab Irrigation Scheme Management Body.

(2) Kitiab Irrigation Scheme Management Body

The table below shows the O&M budget amount for the Kitiab Irrigation Scheme Management Body. Similarly to Aliab, the O&M budget has increased in Sudanese currency (SDG) in 2018, 2019, and 2020 (however, inflation has risen in recent years). On the other hand, in dollar-equivalent terms, the budgeted amounts for 2019 and 2020 have decreased when compared to the budget for irrigation facilities O&M in 2018. The IMO is funded by the state government and receives revenue from water fee collection. However, Kitiab scheme had more irrigation canal weeding deficiencies (main and secondary canals) than Aliab scheme, and the water fee collection rate is lower in Kitiab. In light of this, the budget may be insufficient. Since the water fee collection rate is lower than in Aliab, it will be necessary to improve the financial situation by improving the collection rate.

Table 15 O&M Budget Amount for the Kitiab Irrigation Scheme Management Body

Item	2018	2019	2020
Total O&M related budget (SDG)	1,939,340	3,562,545	4,872,736
Dollar-equivalent value	102,071	79,168	88,595
Water fee collection rate	60%	54%	54%

Source: Except for the dollar-equivalent values, all figures are based on interviews with the Kitiab Irrigation Scheme Management Body.

(3) New Halfa Irrigation Corporation

The 2020 O&M budget (in SDG) for New Halfa K14 area has increased significantly compared to 2018 and 2019 (however, inflation has risen in recent years). The O&M status of major irrigation facilities (pumping stations and water control facilities in irrigation canals) is generally good (based on direct observation of facilities by field survey staff and interviews with public corporation staff), and the water fee collection rate is high. Therefore, it is assumed that the O&M budget has been secured to some extent, but given that sediment removal and weeding in secondary canals is not sufficient, the budget to cover this aspect may be insufficient.

Table 16 Irrigation Related O&M Budget for New Halfa K14

Item	2018	2019	2020
Total O&M related budget (SDG)	2,220,000	4,920,000	10,730,500
Dollar-equivalent value	123,333	109,333	195,100
Water fee collection rate	n.a.	91%	94%

Source: Except for the dollar-equivalent values, all figures are based on interviews with the New Halfa Irrigation Corporation.

(4) Ministry of Production and Economic Resources, River Nile State (MoPER-RNS)

The table below summarizes the budget data prepared by the River Nile State Government for the O&M of irrigation schemes in the state. While we cannot determine whether the amount

is sufficient, it was approximately 100 million yen in 2018 and nearly 300 million yen in 2020 in Japanese yen. Due to rising inflation rates in recent years, it is unclear whether the budget is actually increasing, and it is difficult to determine whether the state government is allocating enough budget for irrigation facility O&M. However, since the amount of support for Aliab and Kitiab accounts for a relatively large¹² proportion of the total amount, the fact that the O&M budgets for both irrigation areas have been secured to some extent is a positive factor in terms of the financial aspects of irrigation facility maintenance.

Table 17 Amount of Support for Irrigation Schemes by MoPER-RNS

Item	2018	2019	2020
O&M cost support for all irrigation schemes in the state (SDG)	16,243,868 (4,243,000)	87,252,000 (12,894,005)	143,041,956 (10,869,000)
Dollar-equivalent value	902,437	1,938,933	2,600,763
(exchange rate)	18.0	45.0	55.0

Note: Figures in parentheses represent the total amount of support to Aliab and Kitiab areas.

Note: Dollar conversion is based on data from early July of each year.

(<https://www.xe.com/currencycharts/?from=USD&to=SDG&view=5Y>)

(5) Summary of Financial Aspects of O&M

For O&M, the irrigation schemes receive revenue from water fee collection and partial support from the River Nile State Government in the case of Aliab and Kitiab. We believe that financial sustainability has been achieved to some extent, though there is still room for improvement by increasing the water fee collection rate based on the observed lack of weeding in some canals. In the case of New Halfa K14, the New Halfa Irrigation Corporation has jurisdiction and budget under the Federal Ministry of Agriculture and Natural Resources. As one of the national irrigation project areas, this is an important irrigation area, and it is expected that a reasonable certain O&M budget will be allocated on a continuous basis.

Taking the above points as a whole, it is judged that the three schemes have achieved fairly satisfactory O&M budgets. That being said, there is room for improvement in the Aliab and Kitiab's financial situation by increasing the rate of water fee collection.

3.4.4 Current Status of Operation and Maintenance

(1) O&M Status in Aliab

- Irrigation Facilities O&M Plans are being prepared every year and implemented according to the plan. The plan implementation rate is high (90% in 2019, 95% in 2020) (data provided by the IMO).
- Water distribution plans are being prepared and implemented annually.

¹² In 2018, 17.0% for Aliab and 9.2% for Kitiab (26.2% in total); in 2019, 7.5% and 7.3% respectively (14.8% in total); and in 2020, 5.0% and 2.6% respectively (7.6% in total).

- As discussed in the section on O&M Systems and Structures, the implementation status of techniques aimed at strengthening staff capacity of the staff is satisfactory.
- Pumping equipment and control panels in pump stations built or upgraded with grant funds are in good working order and being kept clean.
- Main canals are being weeded and cleaned, and are being maintained at their post-restoration shape. Secondary irrigation canals are also being kept clean (there are few weeds and the shape is appropriate). Canal gates are also in good condition.

Taking the above points as a whole, we can conclude that the O&M in Aliab is very satisfactory.

(2) O&M Status in Kitiab

- Irrigation Facilities O&M Plans are being prepared every year and implemented according to the plan. The plan implementation rate is generally satisfactory (80% in 2019, 85% in 2020) (data provided by the IMO).
- Water distribution plans are being prepared and implemented annually.
- As discussed in the section on O&M Systems and Structures, the implementation status of techniques aimed at strengthening staff capacity of the staff is fairly satisfactory.
- Pumps and pump station interiors are generally in good working order, but not as clean as those in Aliab. One pump is out of commission because its control panel failed due to electrical problems, but it is difficult to procure spare parts in Sudan.
- The main canals are overgrown with weeds and in poor condition. Secondary canals are in the same condition as main canals. The canal's gate is fully operational.

Taking the above points as a whole, the O&M status has some issues due to O&M issues in the pump station, main canals, and secondary canals.

(3) O&M Status in New Halfa K14

- Annual maintenance plans are being documented. However, data on the implementation rate could not be obtained.
- With regard to implementing water distribution plans, records are being kept on whether water is being distributed fairly (however, the actual implementation of water distribution plans is not known).
- As discussed in the section on O&M Systems and Structures, the implementation status of techniques (which were enhanced through both projects) aimed at strengthening staff capacity of the staff is fairly satisfactory.
- Pumps and pump stations are operating at a high level of efficiency.
- The main canals are well-managed, with weeding and sediment removal performed. That

being said, some secondary canals have insufficient sediment removal and weeding. Canal gates are in good condition and are inspected on a regular basis. Except for secondary canals, the O&M of major irrigation facilities is generally adequate.

Taking the above points as a whole, we can conclude that, although there are some problems in the maintenance of secondary canals, the O&M in New Halfa K14 is satisfactory overall.

(4) Summary of O&M Status

Although there are some problems, the overall O&M status of the three irrigation schemes is fairly satisfactory.

(5) Synergistic Effect and External Factors in Ensuring the Sustainability of Both Projects

The primary focus of Grant Aid Projects is facility development. When attempting to implement soft components to enhance the O&M capabilities for facilities, it is implemented as technical support/guidance limited to the initial stage (in the case of this project, only about 1 to 3 months depending on the area). In order to reach the level where the results of capacity building are established, it is necessary continuous utilization/practice of the learned technology for O&M activities. It is judged that the implementation of a Technical Cooperation Project for several years by following the technical support/guidance as soft components of a Grant Aid Project, it resulted in increased capacity, retention, and sustainability (one of the synergistic effects of the Grant Aid and Technical Cooperation projects). Although O&M (weeding) of some irrigation canals is insufficient, securing a budget for irrigation canal O&M is not a problem that can be significantly improved by implementing the two projects, but rather depends heavily on financial support from government agencies and an increase in water fee collection. As such, this is a long-term issue that should be addressed.

As a result of the above, there are some issues with the operation and maintenance of both projects in terms of system/structure, technology, finance, and circumstances. Therefore, sustainability of the project effects is fair.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

In this ex-post evaluation, the evaluation of two projects (both projects) was carried out in an integrated manner.

One of the projects evaluated in this report is the Grant Aid Project "Project for Upgrading Food Production Infrastructure in the Republic of Sudan" and this project was implemented to

contribute to agricultural development in the River Nile and Kassala States by upgrading irrigation facilities and introducing equipment, etc. to ensure a stable supply of water for agriculture while also reducing the burden of operation and maintenance of irrigation facilities.

The other project covered in this report is the Technical Cooperation Project "Capacity Development Project for Irrigation Scheme Management in River Nile State." Based on the results of the above-mentioned Grant Aid Project, this project was implemented with the aims of strengthening the management capacity of Irrigation Management Organizations (IMOs) as well as facilitating appropriate irrigated agriculture in areas targeted by the irrigation scheme through agricultural-related improvements in accordance with an efficient water use plan.

These two projects were aimed at improving irrigation facilities, water resource management capacity, and the technical skills of farmers. Both projects were in line with Sudanese policy priorities such as food security, increased agricultural productivity, and poverty reduction, as well as the need to improve irrigation facilities and strengthen operation and maintenance. These projects were also consistent with Japan's ODA policy toward Sudan, which had identified agricultural development as one of its top priorities. Therefore, the relevance of the two projects is high. The project purpose was largely met by improving irrigation facilities and strengthening their operation and maintenance (O&M) capacity, which improved the stability of agricultural water supply and increased the production and unit yield of major crops in irrigated areas. Furthermore, the overall goal of the Technical Cooperation Project has also been achieved. As a result, we can conclude that the project's effectiveness and impact are high. When both projects are evaluated as a whole, the project cost and duration were both within the planned budget and duration, indicating that the projects' efficiency is also high. As for the sustainability of the both projects, the technical capacity of IMOs in these projects' irrigation areas has been improved and the technical level has been maintained to some extent. There is a need to improve the financial situation by increasing the rate of water fee collection, and some irrigation canals have been found to be in need of maintenance (primarily weeding). Therefore, the sustainability of the project is fair.

Considering the above, both projects are evaluated to be highly satisfactory.

4.2 Recommendations

4.2.1 The following are recommendations to two of the implementing agencies, namely the Aliab Irrigation Scheme Management Body and Kitiab Irrigation Scheme Management Body.

(1) Improvement of the water fee collection rate

The water fee collection rates in 2020 for Aliab, Kitiab, and New Halfa K14 were 79%, 54%, and 94%, respectively. Kitiab, in particular, has a significantly low water fee collection rate of

just 54%. To improve the finances of the IMO in Kitiab and to ensure proper O&M of irrigation facilities (including weeding of canals), it is necessary to take measures to improve this collection rate. Aliab has a collection rate of 79%, but additional measures should be taken to improve this rate. It also needs to strengthen its financial position and conduct proper operation and maintenance of irrigation canals, including canal weeding, to ensure that irrigation water can be delivered to farmlands at the canal's downstream end when needed.

(2) Implementation of proper irrigation canal O&M and securing the necessary budget

The situation varies depending on the target irrigation area, but there are some areas, particularly in the Kitiab and New Halfa K14 areas, where secondary canal weeding and sediment removal was not done properly. This is primarily due to a lack of a sufficient budget for irrigation canal O&M. Inadequate weeding or other canal maintenance may result in irrigation water being unable to reach the downstream ends of the system, resulting in a shortage of irrigation water for farmers and, as a result, poor crop growth. It is necessary to take measures to secure the necessary budget for weeding and sediment removal in secondary canals.

4.2.2 Recommendations to JICA

As a result of this ex-post evaluation, issues were found in the continuity of activities among some farmer groups. If similar activities are to be included in future JICA corporation projects, it will be necessary to review what factors prevented farmer groups from continuing production activities, determine if other factors exist, and consider how to improve activity continuity. Given that extension activities conducted by government agencies have shown a decline in effectiveness following project completion, one strategy for ensuring the continuation and firming establishment of farmer groups' activities could be the use of Japan Overseas Cooperation Volunteers (JOCV), etc. after improving the security situation in Sudan.

4.3 Lessons Learned

Regarding the synergistic effects created by linking a Grant Aid Project and Technical Cooperation Project

In a Grant Aid Project, in addition to the construction of facilities, depending on the project, guidance is provided to strengthen the ability to operate and maintain the facilities constructed under the project. Because the technical guidance period is typically brief, it is difficult for capacity building results to become firmly established. In the case of these projects, we have concluded that strengthening capacity by implementing the Technical Cooperation Project after the Grant Aid Project has resulted in higher levels of capacity strengthening and better sustainability of project outcomes. Additionally, both projects resulted in a generally consistent

supply of irrigation water, which resulted in an improvement in wheat unit production and a considerable expansion in the cropping area of citrus fruits, a cash crop. In addition, financial and technical assistance from the River Nile State Government played an important role in the realization of good outcomes of both projects. The Technical Cooperation Project was started immediately after the completion of the Grant Aid Project, and supports were provided without any time gap. It is judged that this linking cooperation by two projects also contributed to bring better synergistic effects. Accordingly, we can conclude that collaborating on a Grant Aid Project and a Technical Cooperation Project can result in synergistic effects.

Regarding the utilization and dissemination of project results by the state government

MoPER-RNS was one of the counterpart agencies for both projects implemented in the two irrigation areas of River Nile State. Following the completion of the Technical Cooperation Project, the state government promoted widespread adoption of the irrigation facilities' O&M techniques to several irrigation schemes throughout the state, and a positive ripple effect was observed as a result of utilizing the project's outcomes. On the other hand, as for the farmer groups to which the Technical Cooperation Project provided support, although the state government provided support during the project period, there was none after completion of the project. This resulted in some of the trained farmer groups abandoning activities and no new farmer groups were formed or trained. Because this could be due to a variety of issues in the state government's extension system (lack of budget for extension, lack of transportation means, lack of extension worker capacity, etc.), there is a strong need to consider fully the inclusion in project plan of collaboration with government agencies to help solve problems in agricultural extension and farm management.

Setting of evaluation indicators

One of the indicators to express the qualitative effects of the Grant Aid Project was "Food costs in River Nile and Kassala states will reduce as a result of the region's increased food production." One of Sudan's staple foods is wheat which is grown in the three irrigation areas covered by Grant Aid Project. However, Sudan's wheat self-sufficiency rate in 2019 was around 50% with the country relying on imports for the remaining 50%. The price of imported wheat is also heavily influenced by the dollar exchange rate and the rate of inflation. Furthermore, the amount of wheat produced in the three areas targeted by the Grant Aid Project is only a portion of the total wheat production in Sudan, and is not enough to affect the wheat price. If the price of wheat is assumed to be an indicator of food prices, it should be noted that even if wheat production increases in Grant Aid Project areas, it is unlikely to be reflected in wheat prices. As for wheat, there is a government purchase price and subsidy system for farmers in purchasing agricultural inputs, so

the price fluctuation mechanism based on the supply and demand of wheat is difficult to function. Although wheat price is not appropriate as indicator, while an alternative indicator (which we recommend) would be whether or not the increase in agricultural production has ensured an adequate food supply at the farm level.

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.

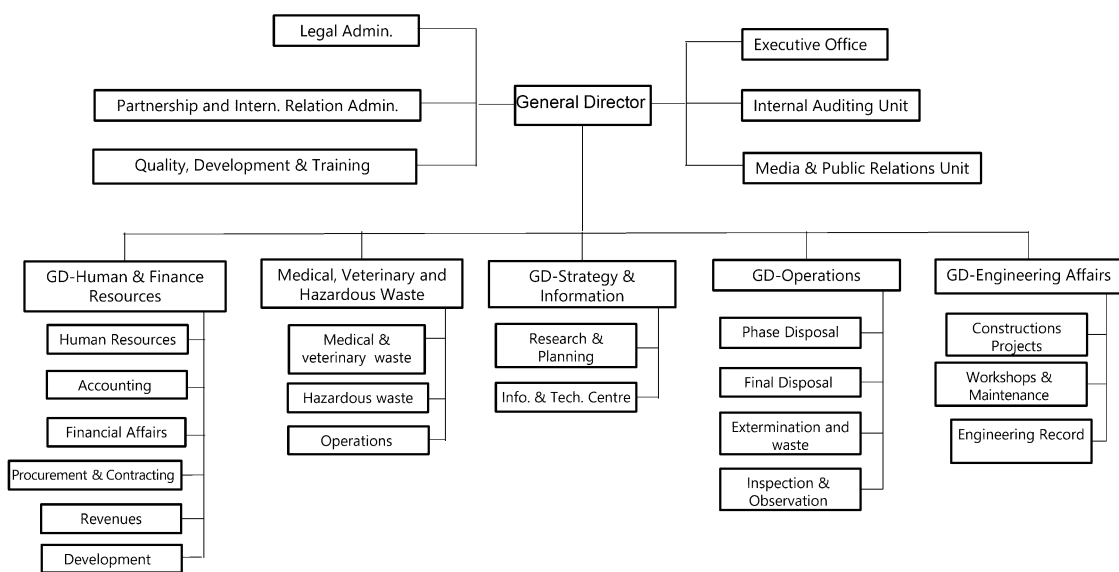


Fig. 1 The KCC Organizational Chart

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	<ul style="list-style-type: none"> ● 3 weekly (average) waste collection 	<ul style="list-style-type: none"> ● 3 weekly (average) waste collection
Bahary	Unknown	<ul style="list-style-type: none"> ● Three-shift system <ol style="list-style-type: none"> 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) 	<ul style="list-style-type: none"> ● 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)	<ul style="list-style-type: none"> ● Garbage collection along major roads. ● Daily collection on major roads, twice weekly collection for branch roads.
Karary	<ul style="list-style-type: none"> ● Over 500 staff (staff + drivers) 	<ul style="list-style-type: none"> ● 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. 	<ul style="list-style-type: none"> ● Residential areas are collected every two days. ● For the market, etc., twice a day.
Omdurman	<ul style="list-style-type: none"> ● 770 staff (101 of which are fee collection teams) 	<ul style="list-style-type: none"> ● 7-day week (Friday: 50% (rolling stock) operation), 24H, 3-shift system ● 3-shift system <ol style="list-style-type: none"> ① 7:00-15:00 ② 15:00-18:00 ③ 19:00-2:00 	<ul style="list-style-type: none"> ● Commercial areas and areas along the main roads (including residential areas) are also collected during night time hours.
Sharg En Nile	Unknown	<ul style="list-style-type: none"> ● 6-day week (except Friday), 8-hour work system with 1-shift system (because of insufficient salary). 	<ul style="list-style-type: none"> ● Collected daily along major roads, along branches, and in the market.
Um Badda	<ul style="list-style-type: none"> ● 945 staff (147 of which are fee collection teams) 	6-day week, 2-shift system. Friday is one shift to 14 o'clock.	<ul style="list-style-type: none"> ● 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.

End