

**THE REPUBLIC OF KENYA
WATER RESOURCES AUTHORITY**

**THE REPUBLIC OF KENYA
KENYA WATER RESOURCES EXPERT
PROJECT**

COMPLETION REPORT

OCTOBER 2024

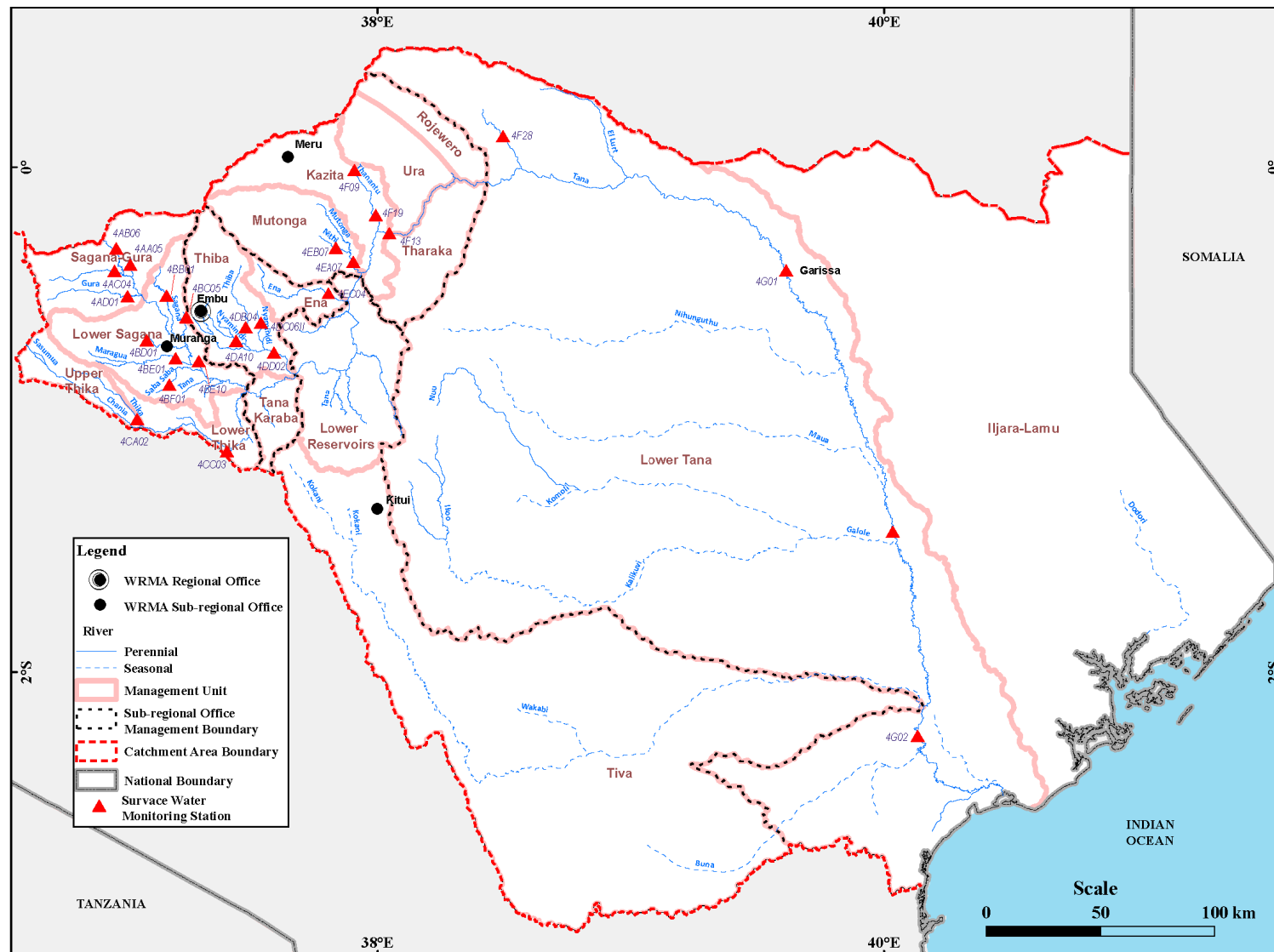
JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.

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Location Map of the Target Area of the Project



Location Map of the Tana Catchment

**Republic of Kenya
Water Resources Advisor
Completion Report**

Location Map of the Target Area for the Project

Location Map of the Tana Catchment

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Abbreviations

BO	:	Basin Office
CEO	:	Chief Executive Officer
CMIP3	:	Coupled Model Intercomparison Project Phase 3
CMS	:	Catchment Management Strategy
CP	:	Counterpart Personnel
FTP	:	File Transfer Protocol
GCM	:	Global Circulation Model
GIS	:	Geophysical Information System
HQ	:	Headquarters
ICT	:	Information and Communication Technology
JAXA	:	Japan Aerospace Exploration Agency
JICA	:	Japan International Cooperation Agency
KMD	:	Kenya Meteorological Department
KWSCRIP	:	Kenya Water Security and Climate Resilience Project
LTE	:	Long Term Evolution
M/P	:	Master Plan
MIDST	:	Monitoring for Information and Decision using Space Technology
MS	:	Monitoring Sheet
MWSI	:	Ministry of Water, Sanitation and Irrigation
NWF	:	Nairobi Water Fund
NWMP	:	National Water Master Plan
NWRMS	:	National Water Resources Management System
O&M	:	Operation and Maintenance
RGS	:	Regular Gauging Station
RRI	:	Rainfall Runoff Inundation
SBO	:	Sub-basin Office
SWO	:	Surface Water Officer
USAID	:	United States Agency for International Development
UTNWF	:	Upper Tana Nairobi Water Fund
WB	:	World Bank
WRA	:	Water Resources Authority
WRUA	:	Water Resources Users Association

Units**Length**

mm	=	millimeter
cm	=	centimeter
m	=	meter
km	=	kilometer

Area

ha	=	hectare
m ²	=	square meter
km ²	=	square kilometer

Volume

l, lit	=	liter
m ³	=	cubic meter
m ³ /s, cms	=	cubic meter per second
CM	=	cubic meter
MCM	=	million cubic meter
BCM	=	billion cubic meter
m ³ /d, cmd	=	cubic meter per day
BBL	=	Barrel

Weight

mg	=	milligram
g	=	gram
kg	=	kilogram
t	=	ton
MT	=	metric ton

Time

s	=	second
hr	=	hour
d	=	day
yr	=	year

Money

KSh	=	Kenya shilling
US\$	=	United States of America dollar
¥	=	Japanese Yen

Energy

kcal	=	Kilocalorie
kW	=	kilowatt
MW	=	megawatt
kWh	=	kilowatt-hour
GWh	=	gigawatt-hour

Others

%	=	percent
o	=	degree
'	=	minute
"	=	second
°C	=	degree Celsius
cap.	=	capital
LU	=	livestock unit
md	=	man-day
mil.	=	million
no.	=	number
pers.	=	person
mmho	=	micromho
ppm	=	parts per million
ppb	=	parts per billion
lpcd	=	litter per capita per day

1 Project Outline

1.1 Background

Under the long-term national development plan, "Kenya Vision 2030," water is identified as an essential resource to support the country's development agenda. Furthermore, the Constitution espouses the "protection of the environment and natural resources with a view to establishing a durable and sustainable system of development."

Under the circumstances of drastic changes related to the water sector, a study titled National Water Master Plan 2030 (NWMP 2030) was conducted by the Water Resources Management Authority (WRMA: former governmental agency now renamed as WRA), as the executing agency, with assistance from the Japan International Cooperation Agency (JICA) during the period from October 2010 to November 2013. The study supported the formulation of water resource development and management plans for all six basin areas in the country, as well as the formulation of action plans to strengthen water resource management capacity.

Among the six major basin areas, the Tana basin area is close to the capital, Nairobi, and its upstream area is blessed with abundant water resources. With the aim of strengthening water resource management through proper monitoring, JICA implemented the "Water Resources Management Advisory Service" (Previous Advisory Service) from January 2017 to September 2019, in the Tana basin area as a pilot basin area (see the figure at the beginning of this document for details of the river basin).

Various activities were carried out during the Previous Advisory Service, including flow observation and installation of water level gauges, which contributed greatly to improving the capacity of staff at the Water Resources Authority (WRA) Headquarters, the Tana Basin Office, and five sub-basin offices. However, for the WRA to quickly implement the plans proposed in the National Water Master Plan 2030 and to carry out the duties stipulated in the New Water Act 2016, it is urgent to build on the previous activities and go beyond to further improve the technical level of WRA staff.

1.2 Objectives of the Project

Based on the background mentioned in the preceding section, the objectives of the activities are as follows:

Aiming at strengthening water resources management, skill-up objectives are targeted as listed below:

1. Strengthening of observation network.
2. Improving and stabilizing capacities related to data observation, arrangement, storage, and analysis.
3. Utilizing observed results to address water resource-related issues such as floods, droughts, and climate change.

1.3 Upper Goal of the Project

Strengthening the water resources management capacity of the WRA staff.

1.4 Goal of the Project

Strengthening of WRA's staff capacity on hydrological data management (observation, arrangement, storage, analysis, and utilization).

1.5 Expected Outputs

As per the Work Plan, the following four major outputs are expected as a result of the JICA experts' activities:

Output 1: Hydrological Monitoring Network Update in Accordance with the Purpose of Monitoring at the Tana Basin Area

Output 2: Capacity Building on Hydrological Monitoring

Output 3: Capacity Building on Arrangement and Storage of Hydrological and Meteorological Data

Output 4: Capacity Building on Analysis and Utilization of Hydrological and Meteorological Data

1.6 Expected Outputs and Activities

In order to achieve the abovementioned outputs, more concrete items are designated as "Activities", as described below:

Output 1 Hydrological Monitoring Network Update in Accordance with the Purpose of Monitoring at the Tana Basin Area

Activity 1.1 Survey on recent flood and drought damages, as well as countermeasures for such damages

Activity 1.2 Survey on support activities by other development partners in the field of water resources

Activity 1.3 Clarification of the positions and purposes of each observation station from the viewpoint of flood and drought risk evaluation

Activity 1.4 Review of the monitoring plan of the Tana Catchment area from the viewpoint of effective utilization of observation results

Output 2 Capacity Building on Hydrological Monitoring

Activity 2.1 Confirmation of the operational status and analysis of issues related to observation facilities and data transmission facilities

Activity 2.2 Support for the preparation of an operational plan for data transmission facilities

Activity 2.3 Training on observation facilities and data transmission facilities

Activity 2.4 Reinforcing capacity on-site observations, including preparation of H-Q curve

Output 3 Capacity Building on Arrangement and Storage of Hydrological and Meteorological Data

- Activity 3.1 Quality improvement guidance and preparation of quality control standards
- Activity 3.2 Confirmation of the current status and improvement of the operation and management of the database

Output 4 Capacity Building on Analysis and Utilization of Hydrological and Meteorological Data

- Activity 4.1 Guidance on Basic Analysis: Implementation of flow regime arrangement/compilation and probabilistic analysis
- Activity 4.2 Analysis of the effects of climate change
- Activity 4.3 Discussion and compilation of the functions of WRA, as well as the utilization and analysis of monitoring results during droughts
- Activity 4.4 Discussion and compilation of measures to be taken during droughts, as well as the utilization and analysis of monitoring results
- Activity 4.5 Discussion and notification to related organizations on the hydrological and meteorological data

1.7 Project Area

The Project activities were mainly conducted at the head office of WRA. On the other hand, as for the field activities, both parties of WRA and the JICA Expert Team agreed that Tana Catchment should be selected among the six catchments through a series of discussions after commencement of the Project.

1.8 Relative Organization

- (1) Responsible agency : Ministry of Water, Sanitation and Irrigation (MWSI)
- (2) Implementing agency : Water Resources Authority (WRA)

1.9 Schedule

The original schedule of the Project was set for approximately 36 months, from April 26, 2021, to April 26, 2024. During the course of the JICA experts' activities, there were some periods in the year 2022, from the middle of June to the middle of November, when the travels to Kenya were restricted by the JICA Kenya Office to avoid inefficiency in activities due to the presidential election. In this connection, the JICA experts' activity period was extended to October 2024.

The JICA Expert Team submitted the Work Plan on July 13, 2021 to WRA as the first draft. No particular comments have been provided by WRA regarding the submitted Work Plan.

1.10 Counterpart Personnel

As per the Work Plan submitted on July 13, 2021, the JICA Expert Team requested the nomination of counterpart personnel to conduct and coordinate activities designated by JICA. Affected by the spread

of COVID-19 to some extent during the first and second field assignments in June and October 2021, the nomination of counterpart staff was made in November 2021, as per the memo of the Technical Manager of WRA. The following personnel were nominated as counterparts:

Table 1-1 Nominated Counterpart Personnel

Name	Position	Organization
Jared Otieno	Team Leader	WRA Headquarters
Ken Ochieng	Counterpart	WRA Headquarters
Augusta Wanja Njuguna	Counterpart	WRA Tana Basin Office
Jane Wanja Njuguna	Counterpart	WRA Kerugoya Sub-basin Office
Alex Mugo Kimotho	Counterpart	WRA Meru Sub-basin Office
Faith Wanja Mbathi	Counterpart	WRA Muranga Sub-basin Office

(Source: JICA Expert Team)

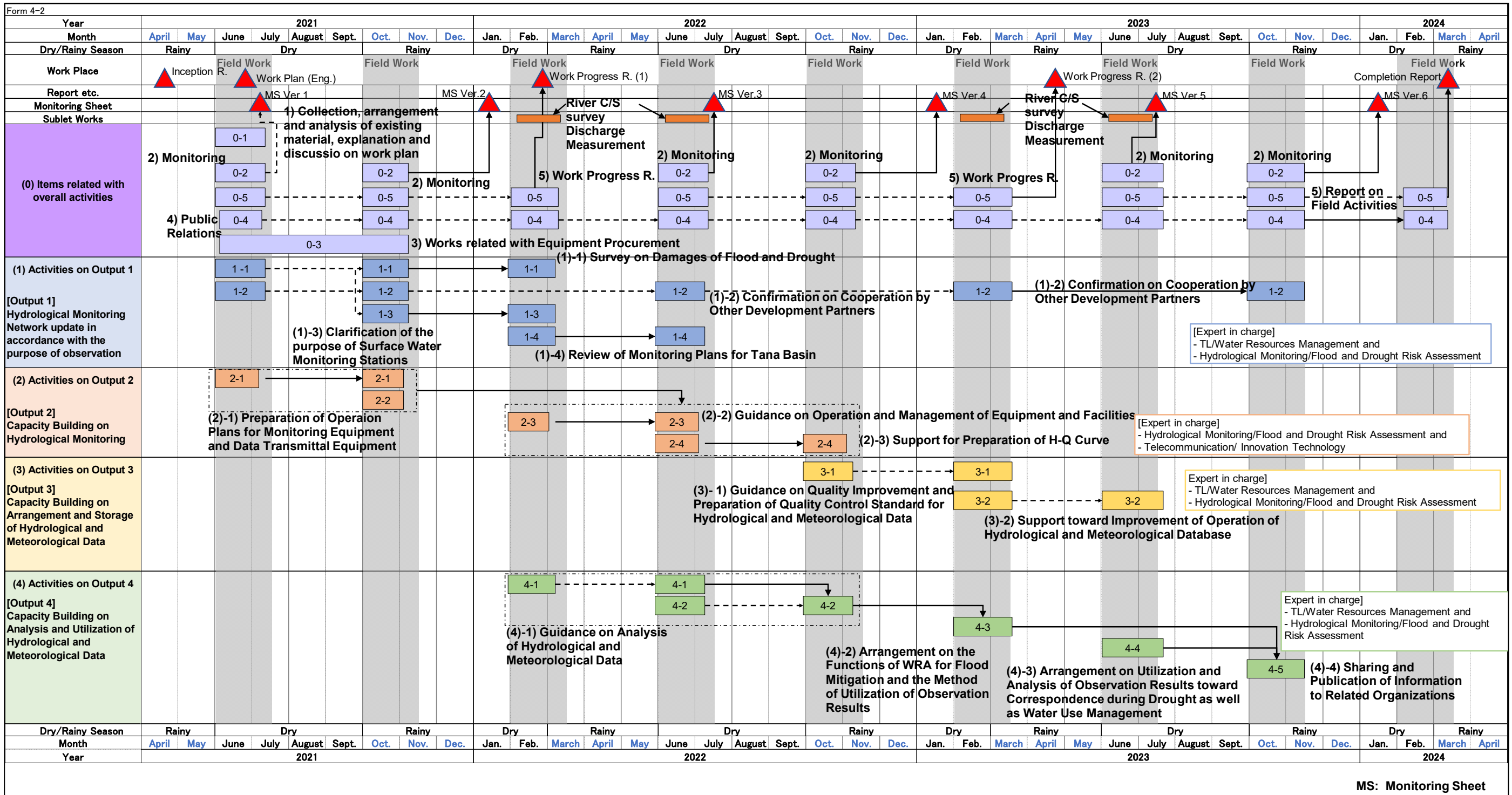
Of the abovementioned counterparts, there were some changes due to personnel transfers; however, the counterparts listed above were mainly in charge of the surface water and carried out capacity-building activities. In addition to these counterparts, other staff members participated in the capacity-building lectures at the Tana Basin Office, on-site discharge measurement, and river cross-section surveys, so that as many counterparts as possible could be trained.

Ms. Augusta Wanja Njuguna, listed as number four in the list above, has been transferred, so the actual work has been carried out by Mr. Samuel Ndungu. Additionally, Ms. Faith Wanja Mbathi, listed as number six on the list, was scheduled to retire in December 2023; therefore, Ms. Jane Wairimu Njoroge has been in charge instead.

1.11 Overall Work Plan

1.11.1 Work Schedule

A flow chart of the original work schedule is shown in Figure 1-1.



(Source: JICA Expert Team)

Figure 1-1 Original Work Flow (At the Start of the Project)

Figure 1-2 Revised Work Flow (At the Completion of the Project)

1.11.2 Staffing

The JICA Expert Team was composed of three Japanese experts, one secretary, and three national assistants. The members of the team and their assignments are presented in Table 1-2. The actual assignment periods of the individuals are tabulated in Table 1-2. Initially, in the composition of national assistants, a “Public Relations” position was included. However, due to short assignment period and lack of suitable candidate, the secretary assumed the responsibilities of the role. The secretary was also in charge of public relations, including the preparation and issuance of newsletters.

Table 1-2 Composition of the Team Members and Assignment Period

Category	No.	Position	Name	Assignment Period
Japanese Experts	J1	Team Leader/Water Resources Management	Takeshi OKAMURA	April 2021 to October 2024
	J2	Hydrological Monitoring/ Flood and Drought Risk Assessment	Yusuke KATO	April 2021 to October 2023
			Yuichi UEDA	October 2023 to November 2023
			Yuki OKADA	December 2023 to October 2024
	J3	Telecommunication/ Innovation Technology	Yasushi AZUMA	April 2021 to October 2024
National Assistants	N1	Water Resources Specialist (Supporting Staff for Team Leader)	Gilbert Maiyo Chumo	March 2022 to October 2024
	N2	Hydrologist (Supporting Staff for Hydrological Monitoring)	Denis Masika	March 2022 to October 2024
	N3	Communication Specialist (Supporting Staff for Telecommunication)	Eugen Mwandoe	March 2022 to October 2024
	N4	Secretary	Doreen Illuba	March 2022 to October 2024

(Source: JICA Expert Team)

2 Project Activities

2.1 Activities of Output 1

Activities of Output 1 are composed of the following four subjects:

Output 1 Hydrological Monitoring Network Update in Accordance with the Purpose of Monitoring at the Tana Basin Area

- Activity 1.1 Survey on recent flood and drought damages, as well as countermeasures for such damages
- Activity 1.2 Survey on support activities by other development partners in the field of water resources
- Activity 1.3 Clarification of the positions and purposes of each observation station from the viewpoint of flood and drought risk evaluation
- Activity 1.4 Review of the monitoring plan for the Tana Basin Area from the viewpoint of effective utilization of the observation results

Actual achievements for each item are as described below:

2.1.1 (Activity 1.1) Survey on Recent Flood and Drought Damages, as well as Countermeasures for Such Damages

The JICA Expert Team conducted a survey to assess how the WRA is responding to flood and drought damages and the current situation. During the field survey, the team collected the following information through interviews with the Tana Basin Office and the sub-basin offices.

(1) Marking of River Water Levels during Flood (Riparian Marking)

During an interview at the Muranga Sub-basin Office of the Tana Basin Area on January 27, 2023, the JICA Expert Team learned that the office is promoting “riparian marking” activities to prevent flood damage. By marking the highest flood level in the past with concrete posts, the office aims to warn people not to cultivate or build houses below the flood level. These riparian marking activities are described in Attachment 5: Site Work Reports, based on the results of a field survey conducted from January 25 to 27, 2023, along with photos. A representative photo is shown on the right.

According to the staff of the Muranga Sub-basin Office, these activities were carried out from June to August 2022. Photos of the activities were provided by the staff of the Muranga Sub-basin Office.



Riparian marking activities in the Muranga Sub-basin Office. Under the guidance of WRA staff, residents are installing concrete posts indicating the maximum water level during floods.

(Source: WRA Muranga Sub-basin Office)

Figure 2-1 Riparian Marking Activities

(2) Rationing Activities during Drought

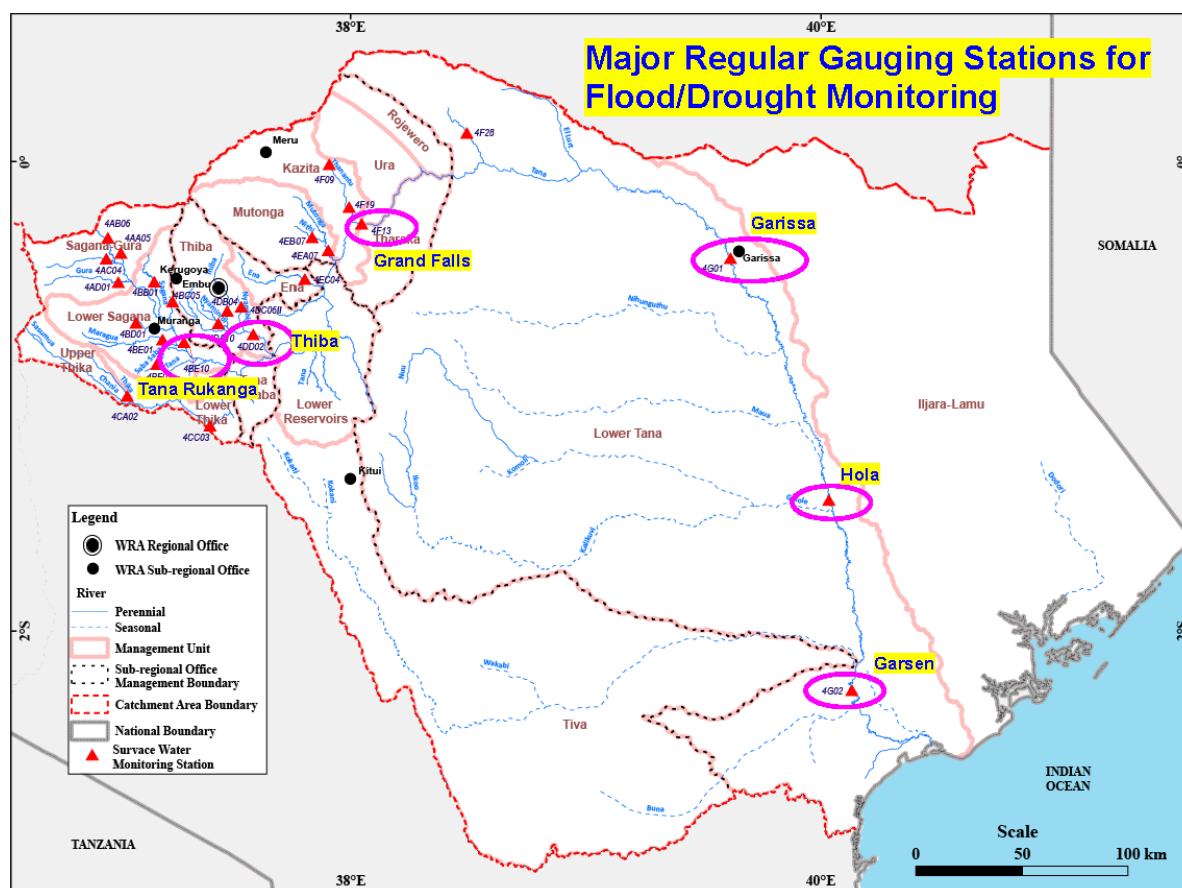
According to interviews at the Tana Basin Office and the Muranga Sub-basin Office, the WRA plays a role in rationing (adjustment of water uses) activities during droughts. Specifically, when the water level falls below a certain threshold, the WRA goes into drought adjustment mode, completely stopping irrigation water intake during the day and instructing water intake at night. In addition, the WRA imposes a certain percentage water intake restriction on each water user.

(3) Flood and Drought Specific Gauging Stations

According to an interview with the Tana Basin Office, the following six gauging stations are used for flood and drought monitoring in the Tana River basin:

- a) 4BE10 Tana Rukanga
- b) 4G01 Garissa
- c) 4G04 Hola
- d) 4G02 Garsen
- e) 4F13 Grand Falls
- f) 4DD02 Thiba

The locations of the above stations are as shown below.



(Source: JICA Expert Team)

Figure 2-2 Locations of Flood and Drought Specific Gauging Stations

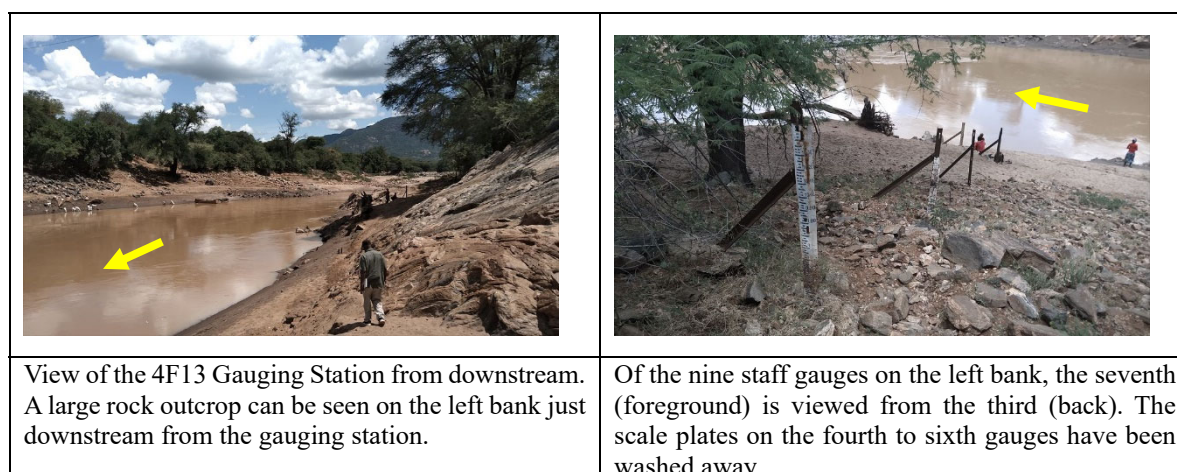
Of the six stations mentioned above, in order to predict floods downstream of Garissa, a study was conducted to determine if a sensor could be installed at the 4F13 Grand Falls Observation Station, and a flood warning could be issued downstream. During the 6th field work, from May 22 to 24, 2023, both experts, the “Team Leader/Water Resources Management” and the “Communications/Innovation Technology”, visited the site. The results of the field survey are shown in Attachment 5: Site Work Reports.

A possible system to be installed at the site was considered, and the system configuration shown in Figure 2-4 was assumed. The study was carried out in consultation with Japanese manufacturers after the “Communications/Innovation Technology” expert returned to Japan.

As a result of the study, it was determined that the installation and operation in Kenya would be difficult for the following reasons:

- Many of the coin-type sensors were prototypes for demonstration tests, and new designs would be required for expansion into overseas markets, which would require additional costs and time.
- As a technical challenge, if low-power communication is applied instead of Bluetooth, certification for frequency use in Kenya would be required (which takes time).
- Similarly, 4G/LTE was expected to be used to transmit data to the WRA Office, but it would be costly to change to 4G/LTE (European specifications) in Kenya (changing the interface from Japanese specifications to European specifications).
- Japanese manufacturers created the system in Japanese, so it is difficult to translate it into English.

Regarding capacity building for the telemetry equipment, it was decided to use observatories with existing telemetry equipment. A letter to this effect was prepared and sent to the WRA President.



(Source: JICA Expert Team)

Figure 2-3 Situation of Regular Gauging Station of 4F13 Tana Grand Falls in the Tana Basin

The results of the study are detailed in "Change of Telemetric Observation Station for Capacity Building on Flood Monitoring" in Attachment 7. In addition, the field survey report for the selection of observation stations for monitoring conducted from May 22 to 24, 2023, is provided in Attachment 5, "Site Works Report."

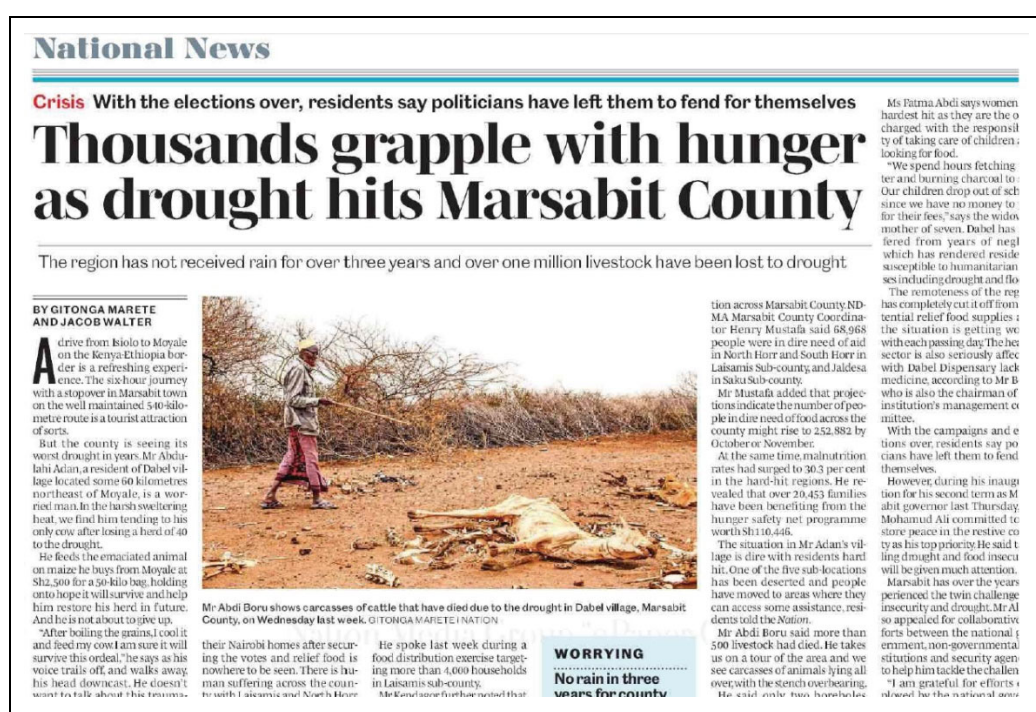
(4) Collection of Newspaper Articles on the Current Situation of Floods and Droughts

As for the situation of flood and drought damages, the JICA Expert Team collected related articles from the local English newspaper, Daily Nation. Articles related to floods, droughts, and other topics were collected from April 2022 to July 2024 and compiled in Appendix 2.

A total of 165 articles were collected during this period.

Articles on floods and droughts were collected not only in the Tana River basin but also nationwide. Roughly categorized, there are 78 articles related to floods, 32 articles related to droughts, 33 general water-related articles, and 12 articles related to climate change. Note that this classification derives keywords from the content of the articles, so some articles contained two or more topics.

From the classification of articles, it can be concluded that Kenya suffered from severe drought damage nationwide from 2022 to 2023. Additionally, it can be observed that flood damage was severe from the second half of 2023 to May 2024, and there were many related articles.



A newspaper article about drought, published on August 29, 2022 in the Daily Nation

SATURDAY NATION NOVEMBER 25, 2023 14

Special Report

Crises Destruction by raging waters has left many travellers stranded and residents of many villages marooned

Several dead, roads closed as floods cause more havoc

In Makueni County, rescue efforts are ongoing after seven people were swept away on Thursday in River Muoni

BY NATION TEAM

A dark cloud hung over the Mutyambua region in Makueni County yesterday after a swollen River Muoni swept away seven villagers on Thursday night as details about them emerged. Their relatives identified three bodies recovered in Ndhiruni and Kavete villages, about 40 and 60 kilometres respectively downstream, dimming any hopes of finding the others alive.

Urbanus Kyalo, the county fire officer who led the rescue and recovery mission, said the bodies of Agnes Muryaa, Rhoda Kimani and Mwila Ndiranga were recovered and identified by their relatives at Makindu Sub-County Hospital mortuary. Esther Mutisi, Emma Mulei, Dorcas Mutuku and Jimmy Ngutu were still missing, he added.

The seven were part of a larger group that was returning home after a meeting with First Lady Rachel Ruto at Kasarani in Nairobi. On reaching Kavuthu township, sources said, a team of nine people who were determined to cross to the Mutyambua side ignored warnings that the river had swollen following a downpour.

"The nine held hands and started to wade through the raging waters. We responded swiftly and rescued two of them who fell into the river. The rest turned down our concerted efforts to rescue them. They claimed we were out to sacrifice them."

They had perched on a tree trunk floating in the middle of the river after being overwhelmed. A sudden swelling of the river engulfed them before sweeping them away as we watched from the banks helplessly," said Mathew Mutiso, one of the local swimmers who had offered to help.

from Garissa town. Whereas the Garissa-Mombasa highway would have served as an alternative route, flash floods on Thursday morning swept away the road at Dukarotiti, 45km from Garissa County, hence ending the dream of entry or exit.

Hundreds of motorists and passengers had to turn back. Buses from Lamu, Garsen, Hola, and Bura were forced to return with their passengers.

"I left home at 3am. I was going to Nairobi to attend to a patient I have at the Korrupia National Hospital. I didn't see this coming," said Hawaa Mohamed, a passenger.

Parents are worried that their children, who have been sitting the KCSE exam, may not make it back home as the crisis deepens.

The Nairobi-Garissa highway has been broken into three sections at Farabore, Arer and Tula, and the bridge at Tula currently hangs on to slim hopes. Hundreds of trucks ferrying food have parked on the road, snarling them to exchange goods with trucks across. More than 100 buses ferrying people have been affected, forcing passengers to alight and wait for the water to subside before they can swim across.

"I have come so far and cannot just go back. I will wait here until I can cross later on, others have managed it so shall I," said Hawaa Salim, a stranded passenger.

Paul Mwerndwa, a truck driver, notes that if the situation does not settle early enough, he will lose goods worth Sh7.3 million. "I have perishable goods here with me, and they are headed for Hela and Lamu. This is my second day in this struggle. I may have to go back, but it still will be a loss," he said.



Swimmers help a student cross River Muoni in Kavuthu township, Makueni County, yesterday. This is where the swollen river swept away seven people on Thursday night. PLUS MAUNDU/ NATION



A woman with a child wades through a flooded Bura-Garissa highway. STEPHEN ODUGRI/ NATION

A newspaper article about flooding, published on November 25, 2023 in the Daily Nation

2.1.2 (Activity 1.2) Survey on Support Activities by Other Development Partners in the Field of Water Resources

To avoid duplication of activities, it is essential to communicate with other development partners for information collection and sharing. During the JICA Expert Team's activities, communications were made with the following organizations.

1. Kenya Water Security and Climate Resilience Project (**KWSCRP**) supported by the World Bank: Flood Warning System and Watershed Management Components of the **Nzoia River** in the Lake Victoria North Basin Area
2. Capacity Development for Effective Flood Management in Flood-prone Areas (**CDEFM**) implemented by **JICA from 2011 to 2014**, and Flood Control Officers (FCO) in WRA: Completed.
3. **Groundwater Survey by USAID** in South Turkana and Marsabit
4. Monitoring for Information and Decision using Space Technology (**MIDST**)
5. Nairobi Water Fund (**NWF**)
6. **Blue Deal** Upper Tana

The activities and interactions conducted with the above organizations are described hereunder.

(1) KWSCRIP

As this was a program supported by the World Bank, and their office was on the first floor of the WRA building, close to the JICA Expert Team's office, the team frequently exchanged information during fieldwork. The team held interviews for information exchange on July 1, 2, and 12, 2021, during the first fieldwork. During the interviews on July 1 and 2, the work of the JICA Expert Team was explained and the other party activities were heard about. At the meeting on July 12, the JICA Expert Team reported on the results of their inspection of the water level observation stations in the Upper Tana River basin and collected information on whether there were any suitable locations for flood forecasting and warning.

(2) Groundwater Survey by USAID

The JICA Expert Team was informed by the officer in charge of groundwater at the Ministry of Water, Sanitation and Irrigation about a USAID-funded survey for groundwater development being conducted in Marsabit and Turkana, and the team met with him twice. Since the JICA Expert Team's activities were mainly focused on surface water and covered a large target area, they could only obtain general information about groundwater.

(3) Monitoring for Information and Decision using Space Technology (MIDST)

The outline of MIDST is described hereunder.

In September 2019, the Group on Earth Observations (GEO) and Google Earth Engine (GEE) announced a call to action for GEO member countries to apply for Earth observations projects monitoring the pulse of the planet for the GEO-GEE Program. Kenya is a member of GEO and is represented on the Programme Board by Kenya Space Agency.

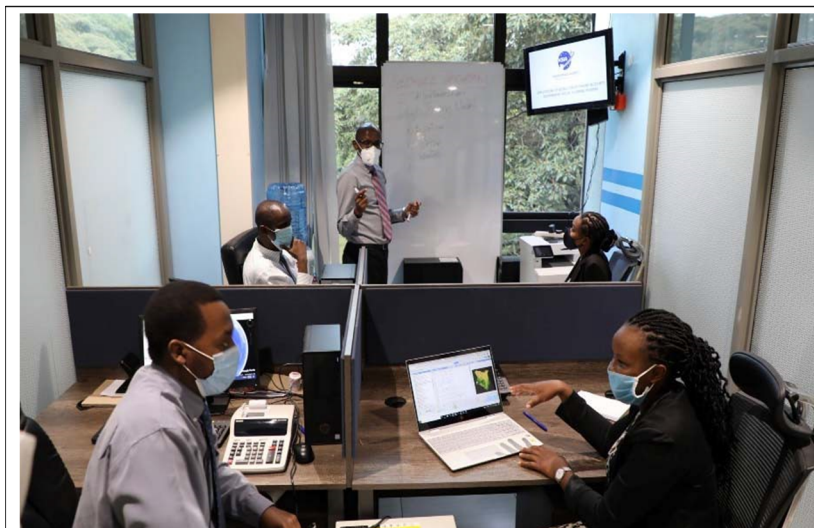
Kenya Space Agency submitted an application to support the national government, and more particularly the county government, in spatial planning, natural resources management, and disaster mitigation. The GEO received more than 50 projects from around the globe on a range of social and environmental topics, including climate monitoring, water and coastal observations, sustainable development, and other key areas related to environmental protection and conservation. Two of these applications were from Kenya.

On July 14, 2020, the GEO and GEE announced 32 projects from 22 countries. The application by the Kenya Space Agency on "Natural Resources Management," which has since been renamed "Monitoring for Information and Decisions using Space Technology – MIDST," was one of the selected projects to benefit from the award.

The award is in place for two years and aims to produce tangible societal benefits by the power of Earth observations coupled with GEE. With the support of EO Data Science, beneficiaries will receive in-kind technical support, mentoring, and ongoing capacity development to ensure the projects achieve their intended impact.

The MIDST project, the beneficiary of this award, is a project conceived by the Kenya Space Agency and its stakeholders with the aim of leveraging open-source systems and freely available geospatial data to support policy and decision-makers in the country in making decisions and policies supported by requisite data.

Using satellite imagery, the Kenya Space Agency will develop products and resources in three areas of applications, namely: (1) Natural Resource Management (Forest), (2) Spatial Planning (Urbanization), and (3) Disaster Management (Floods/Landslides).



Kenya Space Agency Project team led by Mr. Charles Mwangi (standing) planning the implementation of the GEO-GEE unlimited license award.

"We are honored for having been selected to benefit from the GEO-GEE unlimited license programme. This opportunity offers the Kenya Space Agency a platform to support the county governments in Kenya to develop Earth Observation products and build their capacity on the adoption and utilization of space-derived data in decision making."

Maj. Gen. Thomas Chepkuto, Ag. Director General, Kenya Space Agency.

(Source: <https://earthobservations.org/article.php?id=447>)

After being introduced by the Senior Knowledge Management Officer of KWSCR - Project Implementation Unit of WRA, the JICA Expert Team participated in the first online meeting on May 31, 2022. The theme of the meeting was flood analysis in the middle and lower reaches of the Tana River. During the meeting, the JICA Expert Team provided a brief introduction of their activities. A subsequent meeting was scheduled for the latter half of June 2022, however, despite sharing information through WRA during the project period, the team was unable to attend many meetings after returning to Japan due to time constraints.

In addition, the Kenya Space Agency was invited to an open seminar in Nairobi in September 2024, where both parties exchanged opinions.

(4) Nairobi Water Fund (NWF)

An online meeting was held on January 31, 2023, during the fifth fieldwork period. During the meeting, the JICA Expert Team received an overview of the Nairobi Water Fund's activities and confirmed commonalities and overlaps with their work. NWF is based in Sagana in the Upper Tana Basin and operates as the Upper Tana – Nairobi Water Fund (UTNWF). According to their long-term strategy (2022-2026), the objective of UTNWF is "long-term conservation, protection, and management of the water resources of the Upper Tana River basin and ensuring the safety of water supply to Nairobi." The long-term strategy file is attached in Attachment 8, "Upper Tana - Nairobi

Water Fund Strategic Plan 2022-2026." The UTNWF has installed 18 data loggers for water level observation at the Tana Basin Area, and observations are being conducted. Due to the nature of their activities, it is not feasible to reduce the number of monitoring stations at the Tana Basin Office and Muranga Sub-basin Office.

(5) Blue Deal Upper Tana

As for the Blue Deal Program led by the Dutch government, the timing of the on-site work with the JICA Expert Team did not match up well, and opportunities to exchange information were difficult to realize.

With the help of local staff, the JICA Expert Team connected Nairobi and Tokyo online on September 18, 2023, before the seventh fieldwork period, and exchanged opinions.

Blue Deal is active in the Upper Tana River basin, mainly in the Thika and Muranga basins. One of its activities is the restoration of water gauges and observation stations. The JICA Expert Team was asked whether JICA was considering similar restoration activities. The JICA Expert Team conveyed that JICA was not considering the restoration of existing facilities and would focus solely on capacity-building activities.

Next, capacity-building activities were conducted in the form of a joint workshop held at the WRA Tana Basin Office (Embu) in collaboration with the team dispatched under the Blue Deal Program from September 19 to 20, 2023. The four local staff members of the JICA Expert Team were mainly responsible for the response. For details, refer to Attachment 9 "Site Visit Upper Tana - Capacity Building (18th – 20th September 2023)."

The JICA Expert Team invited the Blue Deal Program to a public seminar in September 2024, but due to the timing of their field assignment, the invitees were unable to attend.

2.1.3 (Activity 1.3) Clarification of the Positions and Purposes of Each Observation Station from the Viewpoint of Flood and Drought Risk Evaluation

(1) Status of Monitoring Stations

During the fourth fieldwork period, the JICA Expert Team visited the Tana Basin Office (BO) and Sub-basin Office (SBO) on two separate occasions – June 2-3 and June 9-10, 2022 – to confirm the status of the monitoring stations and the division of roles between the HQ, BO, and SBO with the surface water officers of each office. The status of the monitoring stations is shown in Attachment 4, "Status of Surface Water Observation Stations (as of June 15, 2022)," and the results of the field survey are presented in Attachment 5, "Site Works Reports." The overview of the observation stations in the three sub-basins (Kerugoya, Muranga, and Meru) in the Upper Tana Basin is as follows.

Although the JICA Expert Team did not conduct any interviews, the status of the Garissa Sub-station is also listed.

Table 2-1 Status of Surface Water Monitoring Stations at the Tana Basin Area

	<i>Total</i>	<i>Operational</i>	<i>Not Operational</i>	<i>Telemetry Station</i>	<i>Data Logger</i>	<i>Vandalized</i>	<i>Need Rehabilitation</i>
<i>Kerugoya</i>	13	13	0	7 (54%)	0	1	2 (15%)
<i>Muranga</i>	53	47	6	11 (21%)	19 (36%)	7	14 (26%)
<i>Meru</i>	16	13	3	3 (19%)	4 (25%)	0	0
<i>Sub-total</i>	82	73	9	21 (26%)	23 (28%)	8	16 (20%)
<i>Garissa</i>	5	3	2	1 (20%)	0	0	0
<i>Total</i>	87	76	11	22 (25%)	23 (26%)	8	16 (18%)

(Source: JICA Expert Team)

The Muranga Sub-basin Office manages the greatest number of observation stations and has two surface water officers (SWOs).

Of the 53 observation stations, 15 are short-term, specific-purpose observation stations, mainly used to monitor riverbank erosion. In addition, five observation stations are used by the Nairobi Water Supply Project, providing data to WRA. The remaining 33 stations are believed to be used to grasp water resource volume. According to the ICT officer at the Tana Basin Office, approximately 70% to 80% of the water resource volume under the jurisdiction of the Muranga Branch is transferred to Nairobi. While it is understandable that observation is necessary for inter-basin water transfer, the necessity of each observation station needs to be confirmed.

(2) Regarding the Necessity of the Existing 87 Observation Stations

During the sixth fieldwork in January 2023, the JICA Expert Team requested the Technical Manager of the Tana Basin Office to compile a report justifying the necessity of maintaining all 87 observation stations. However, no specific response was provided. When the JICA Expert Team inquired with the Technical Manager of WRA Headquarters, he explained that many of the observation stations are already being monitored by related agencies for purposes such as the water supply to Nairobi mentioned above. It was further noted that it is not possible to immediately reduce the number of observation stations.

2.1.4 (Activity 1.4) Review of the Monitoring Plan for the Tana Basin Area from the Viewpoint of Effective Utilization of the Observation Results

As described in Activity 1-3 above, observations are ongoing at the existing 87 stations. During the eighth fieldwork, a workshop was held on February 14, 2024, to discuss the resources required for maintaining observations at all 87 stations. The details are mentioned in Attachment 5, "Site Works Reports" for the discussion materials. Carrying out the river crossing survey and discharge measurement works at all 87 stations would require 4 to 5 staff members working for approximately two months per year. WRA informed the JICA Expert Team that it is currently impossible to carry out the amount of work by surface water staff alone due to personnel arrangements. As a solution, WRA stated they plan to involve local residents and Water Users Associations (WRUAs) to support these operations.

2.2 Activities of Output 2

The activities of Output 2 are composed of the following four subjects:

Output 2 Capacity Building on Hydrological Monitoring

- Activity 2.1 Confirmation of the operational status and analysis of issues related to observation facilities and data transmission facilities
- Activity 2.2 Support for the preparation of an operational plan for data transmission facilities
- Activity 2.3 Training on observation facilities and data transmission facilities.
- Activity 2.4 Reinforcing capacity on-site observations, including preparation of H-Q curves.

The actual achievements for each item are as described below:

2.2.1 (Activity 2.1) Confirmation of the Operational Status and Analysis of Issues Related to Observation Facilities and Data Transmission Facilities

(1) Operational Status on Observation Facilities and Data Transmission Facilities

<Status of Telemetry Station>

On October 26 and 27, 2021, the JICA experts in charge of "Team Leader/Water Resources Management" and "Communications/Innovation Technology" inspected five telemetering stations in the upper reaches of the Tana River. Among these, three stations (4DA11, 4BB01, and 4CC08) were found to be functioning normally. However, one station (4BE01) had stopped operation due to theft or destruction and another station (4DD02) had stopped observations due to equipment malfunction. The telemetering equipment (data loggers) used consist of three types: SEBA, ISODAQ, and Campbell. The three stations that were functioning normally use SEBA (made in Germany). The malfunctioning station (4DD02) used ISODAQ (made in the United Kingdom) equipment, and it appeared that creatures were building nests in the container in which the equipment was stored. Detailed information is available in Attachment 5, "Site Works Reports."

At the WRA Headquarters, the JICA Expert Team inspected the system used for collecting data from each telemetering station. The data is automatically transferred from each observation station to an FTP server at headquarters every hour via the mobile phone network. WRA is currently promoting the telemetry of water level observation stations in each river basin. Additionally, they have requested the JICA Expert Team's cooperation in repairing and enabling telemetry for the water level observation stations.

As mentioned in Activity 1-3 above, during the fourth fieldwork period, the JICA Expert Team inspected the status of the monitoring stations in the Tana River basin area twice, on June 2-3 and June 9-10, 2022. During the inspection on June 9-10, an expert in communication/innovation technology also participated and confirmed the status of the telemetry observation stations and data loggers. The field inspection reports are detailed in Attachment 5, "Site Works Reports."

As aforementioned, there are 22 telemetry observation stations in the entire Tana River basin area. Telemetry observation stations are usually used when data acquisition is difficult in remote areas or when there is a need for instant acquisition and transmission of data to make necessary decisions. In the case of the Tana River basin area, it appears that the stations are being used for the latter reason, especially to quickly acquire and transmit flood data to support evacuation efforts and alike.

When the JICA Expert Team interviewed the Basin Office, the team learned that the equipment was introduced for projects such as KWSCRIP or for joint observations with the Kenya Meteorological Department (KMD) and that the equipment was introduced with these projects in mind.

Most of the telemetry systems installed at the three upstream sub-basin offices (Muranga, Kerugoya, and Meru) were delivered by SEBA, a German product. These systems use data loggers, communication systems, and car batteries. All of the SEBA systems were working normally when they were inspected in October 2021.

In addition to SEBA, a British-made device called ISODAQ was installed at one location (4DD02 Thiba), but it was not working. The cause has not been determined.

The telemetry observation station uses the mobile phone network to transmit measurement data to headquarters every hour. The headquarters processes the measurement data every three hours.

There are no documents related to the delivered products (operation and inspection manuals, test results, specifications, etc.), so the functionality of the products cannot be confirmed. It was necessary to distinguish between product defects, water level gauge defects, and problems with the mobile phone network, so an investigation was carried out by local personnel. In conclusion, the JICA Expert Team advised that consideration should be given to reducing the labor required for maintenance by standardizing the specifications of the equipment.

According to the WRA Headquarters, regular inspections are carried out, but there is no inspection record book. The equipment status (stopped or in operation) is recorded in an equipment ledger (Excel format).

In addition, cleaning of the station building has not been carried out, and there are concerns about the impact on existing equipment.

Given the current operating status, it is recommended that SEBA or a system with equivalent specifications be introduced when establishing a telemetry observation station.

<Outlines of SEBA Telemetry Equipment and Its Specifications>

SEBA telemeters digitally record water levels, water quality, and rainfall. Due to the implementation of state-of-the-art serial flash memory, SEBA can achieve high data capacity and high data security. SEBA also excels in terms of low power consumption and the small size of its electronic circuit boards.

Major specifications are as follows:

- Memory capacity: 16 MB (1,120,000 readings)
- Storage interval: Two minutes to 99 hours
- Channels: Up to 32
- Communication: RS 232 (standard), Bluetooth® (optional)
- Power supply: 12 VDC
- Operating temperature: -40°C to +70°C
- Modem: GPRS/EDGE/UMTS/HSDPA/HSDPA+/LTE (4G)
- Frequency: 800/900/1800/2100/2600 MHz (worldwide)

<Status of Data Logger>

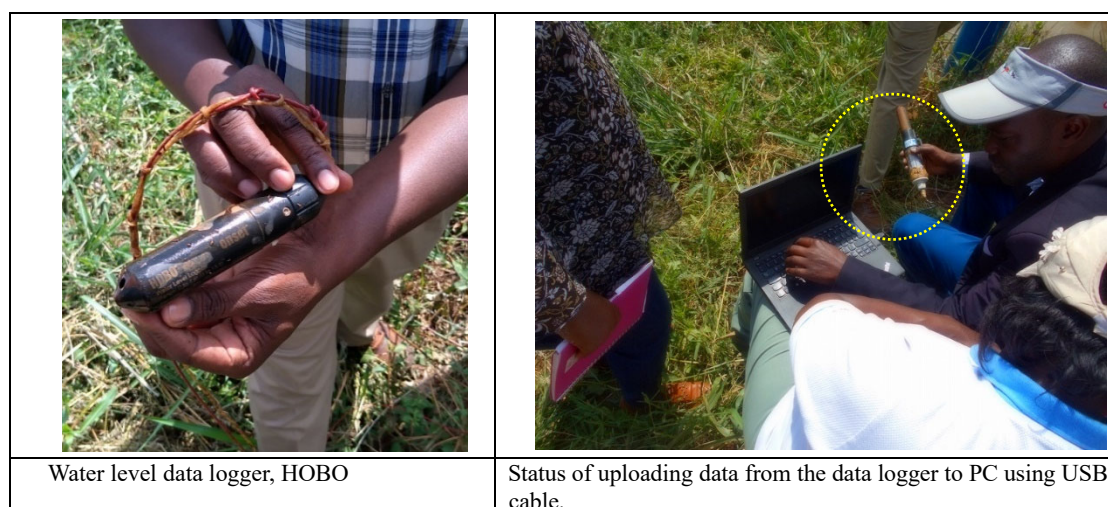
During the fourth fieldwork in June 2022, the JICA Expert Team learned that Nairobi Water Supply is installing new data loggers made by the American manufacturer HOB0 at 19 locations. The team visually inspected the actual device and how to read the measurement data at the 4BE01 (Maragua) Observation Station and then obtained detailed information from the manufacturer at the following URL:

<https://www.onsetcomp.com/products/data-loggers/u201-04/>

According to an interview with the WRA Muranga Watershed Branch, the device costs about KSh 75,000.

This product has an integrated structure of sensor, memory, and battery, and is easy to read data, easy to use, and relatively inexpensive. During the inspection, Ms. Faith Mbat, the Surface Water Officer (SWO) of Muranga Sub-basin Office, was uploading data to a computer with familiarity at the 4BE01 (Maragua) Monitoring Station.

Due to its user-friendly nature, the introduction of this system is recommended.



(Source: JICA Expert Team)

Figure 2-6 Status of Data Loggers

<Specifications of HOBO Data Logger>

The major specifications of HOBO Data Loggers are as follows:

- Type: Pressure type
- Water level operating range: Zero to four meters
- Accuracy: +/- 0.1% FS (0.4 cm FS)
- Battery life (normal use): Five years with logging intervals of one minute or greater
- Memory (non-volatile): 64K bytes (21,700 pressure and temperature samples)

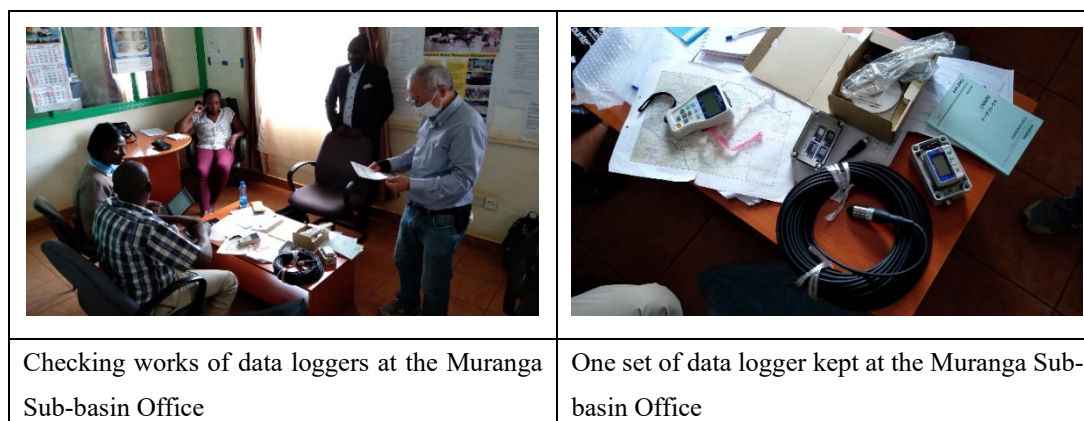
A Japanese-made Hioki data logger is in operation at the 4F10 (Kathita) Regular Gauging Station at the Meru Sub-basin Office, which was installed during the previous advisory work. When this data logger was checked in May 2023 during the sixth fieldwork, it was confirmed that the observation hut had been pried open and the data logger had been taken away. As of February 2024, there are no plans for repair or restoration.

During the fieldwork, the JICA Expert Team confirmed the delivery and usage status of the equipment delivered during the previous advisory work (2017-2019). The status as of September 2024 is as follows.

Table 2-2 Status of Equipment (Data Loggers) Provided during the Previous Advisory Works

No.	Sub-basin Office	Status
1	Meru	The data logger was installed at the Kathita Gauging Station (4F10) and was in operation. However, on May 18, 2023, it was confirmed that the observation hut had been broken into and the data logger was removed.
2	Garissa	Not installed.
3	Muranga	It was installed at the Tana Rukanga Observatory (4BE10) in 2018, but the observatory was destroyed in June 2021, and all equipment was removed.
4	Muranga	Not installed. WRA had hoped to install it as part of this JICA expert mission, but this was not realized as it was outside the scope of the mission.

(Source: JICA Expert Team)



(Source: JICA Expert Team)

Figure 2-7 Checking Works of Data Loggers at the Muranga Sub-basin Office

(2) Missing Data Rate of the Telemetry Equipment

The JICA Expert Team collected data on missingness rates from WRA to confirm the operational status of existing telemetry equipment/systems in August 2022. The collected data is shown in the table below.

Table 2-3 Missing Data with the Telemetry Equipment

No.	Name	Station ID	No of Dataset	Start Date	End Date	Duration of measurement in year	Total number of data measured	Total Number of Data to be Measured	Total Number of Missing Data	Percentage of Missing Data
1	4DA10-THIBA-WATER LEVEL-RAW	4DA10	2126	2021/06/01	2022/03/10		6765	9966	3201	32.1%
2	4DD02-THIBA-WATER LEVEL-RAW (Resampled)	4DD02	599	2017/12/23	2019/08/13		14352	40119	25767	64.2%
3	4BE01-MARAGUA-WATER LEVEL-RAW	4BE01	3776	2021/06/01	2022/07/18		9885	9966	81	0.8%
4	4BE10-TANA-WATER LEVEL-RAW	4BE10	68	2018/12/07	2020/02/10	1.18	10335	31741	21406	67.4%
5	4DA11-THIBA-WATER LEVEL-RAW	4DA11	21116	2020/02/19	2022/07/18		21115	21196	81	0.4%
6	4CA19-KARIMENU-WATER LEVEL-RAW	4CA19	10811	2020/01/18	2021/04/13	1.23	10809	21960	11151	50.8%
7	4CA02-CHANIA-WATER LEVEL-RAW	4CA02	4170	2020/01/18	2020/07/10	0.48	4167	21963	17796	81.0%
8	4CC08-THIKA-WATER LEVEL-RAW	4CC08	6587	2020/02/13	2022/07/06	2.39	20975	21334	360	1.7%
9	4G01-TANA-WATER LEVEL-RAW	4G01	9140	2021/05/27	2022/07/18		10003	10084	81	0.8%
10	4BB01-RAGATI-WATER LEVEL-RAW	4BB01	11534	2019/11/18	2022/07/18	2.66	23339	23420	81	0.3%
11	4DD02-THIBA-WATER LEVEL-RAW	4DD02	20725	2017/12/23	2020/08/28		23504	40119	16615	41.4%
12	4EB11-MARA RIVER-WATER LEVEL-RAW	4EB11	18	2021/06/01	2022/03/17		6948	9966	3018	30.3%
13	4EA06-MUTONGA-WATER LEVEL-RAW	4EA06	17479	2017/11/24	2019/11/22		17478	40800	23322	57.2%
14	4BC02-TANA AT SAGANA-WATER LEVEL-RAW	4BC02	2945	2021/06/01	2021/12/23		4926	9966	5040	50.6%

(Source: WRA)

<Observatories with Large Rate of Missing Data>

The outlines of observatories with a large rate of missing data, the nine sites marked yellow in Table 2-3, are as described in Table 2-4.

Table 2-4 Outlines of Observatories with Large Rate of Missing Data

No.	Name of Site	Missing Data Rate	Remarks
1	4DA10	32.1%	* SEBA telemetry is said to be functional, but it stopped the operation on March 10, 2022.
2	4DD02(Resampled)	64.2%	It stopped the operation on August 13, 2019.
3	4DD02	41.4%	* It stopped the operation on August 28, 2020: Situation on the site was confirmed by the site survey on October 27, 2021.
4	4BE10	67.4%	* It stopped the operation on February 10, 2020: Vandalism on the site was confirmed by the site survey on October 26, 2021.
5	4CA19	50.8%	* SEBA telemetry is said to be functional, but it stopped the operation on April 13, 2021.
6	4CA02	81.0%	* It stopped the operation on July 10, 2020 due to vandalism.
7	4EB11	30.3%	* SEBA telemetry is said to be functional, but it stopped the operation on March 17, 2022.
8	4EA06	57.2%	* ISODAQ telemetry is said to be functional, but it stopped the operation on November 22, 2019.
9	4BC02	50.6%	* SEBA telemetry is said to be functional, but it stopped the operation on December 23, 2021.

(Source: Data from the report "Baseline Survey of Hydrological Networks" prepared by Wasul Solutions & Services Ltd in January 2022)

The source, the Hydrological Network Baseline Survey, states that "telemetry is functional" in five places, but the reason for the high rate of missing data is unclear. The JICA Expert Team asked WRA for the reason but did not receive a clear answer.

<Observatories with Large Rate of Missing Data>

Observatories with a small rate of missing data (5% or less): Telemetry equipment is functioning normally.

Table 2-5 Outlines of Observatories with Small Rate of Missing Data

No.	Name of Site	Missing Data Rate	Remarks
1	4BE01	0.8%	* SEBA telemetry and HOBO data logger are operational well
2	4DA11	0.4%	* SEBA telemetry is operating well
3	4G01	0.8%	** SEBA telemetry is operating well

(Source: Data from the report "Baseline Survey of Hydrological Networks" prepared by Wasul Solutions & Services Ltd in January 2022)

<Considerations>

Operations at the two locations were suspended due to vandalism, and WRA has not independently carried out restoration work on the observation facilities. However, the JICA Expert Team hopes for early restoration.

Note that five observation facilities were reported as having "telemetry functioning." The reason for the high rate of missing data is unclear, but the causes are identified as follows:

- A failure of the telemetry equipment (including batteries)
- A failure of the water level sensor (including cables)
- A malfunction of the mobile phone network, etc.

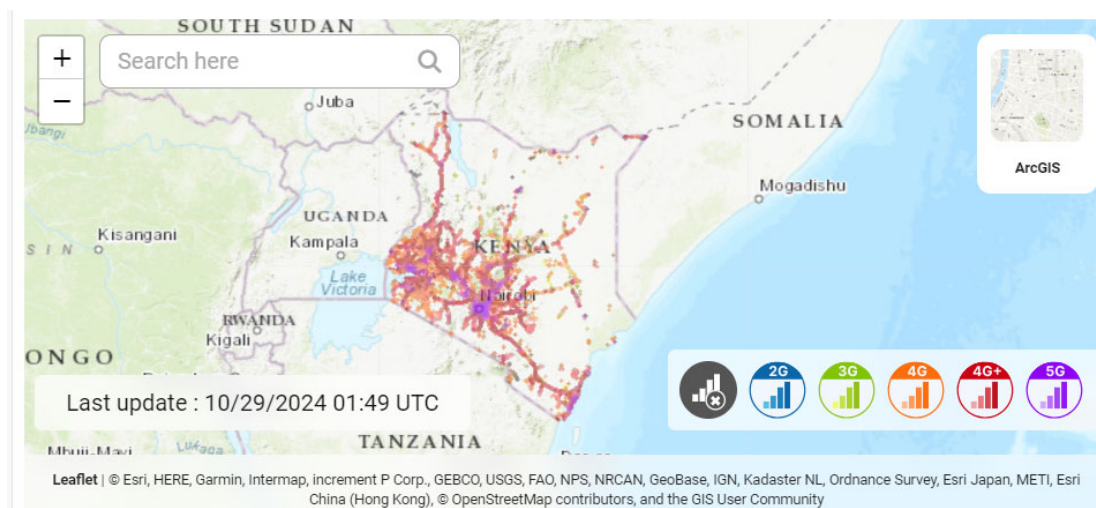
In case the battery is completely discharged, it needs to be charged or replaced.

(3) Availability of 3G/4G Networks

In the telemetry system installed by WRA, the Airtel mobile phone network's 3G/4G network is used for data transmission. For reference, the JICA Expert Team collected the data on the availability of 3G/4G networks from three Kenyan mobile phone companies in the Tana River basin and confirmed the following regarding the use of 3G/4G services:

[Safaricom]

Safaricom covers a wide area, as shown in the figure below, and can be used for the telemetry system.

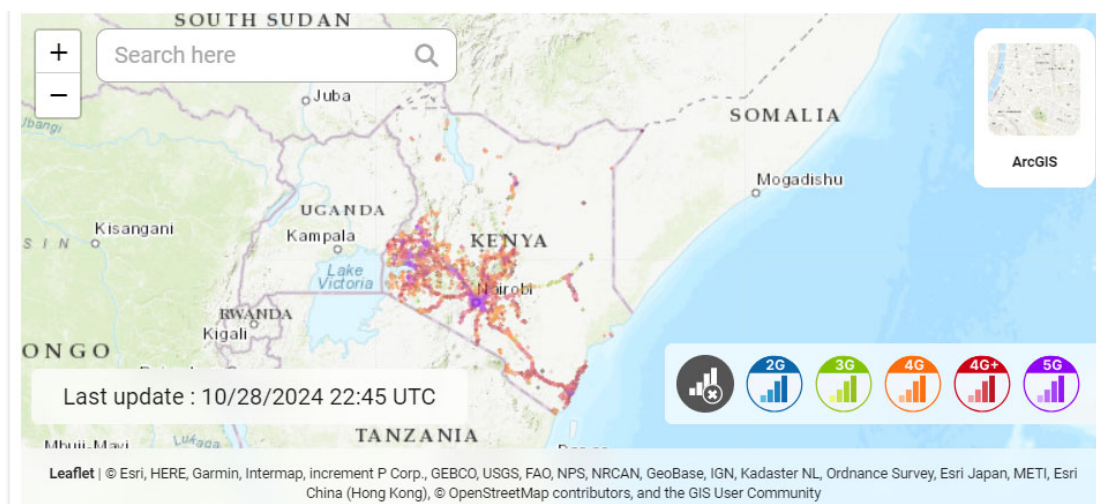


(Source: <https://www.nperf.com/en/map/KE/-/>)

Figure 2-8 Coverage Area of Safaricom Network

[Airtel]

Airtel has a smaller coverage area than Safaricom, as shown in the figure below, but within the range, it can be used as a telemetry system.

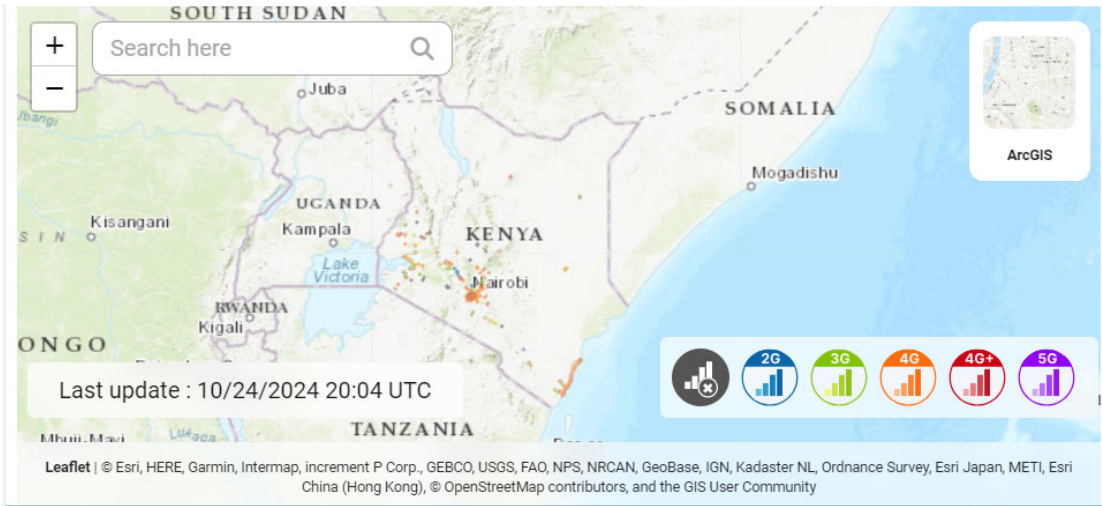


(Source: <https://www.nperf.com/en/map/KE/-/>)

Figure 2-9 Coverage Area of Airtel Network

[Telkom]

As shown in the figure below, Telkom has a small coverage area and is not considered suitable for a telemetry system.

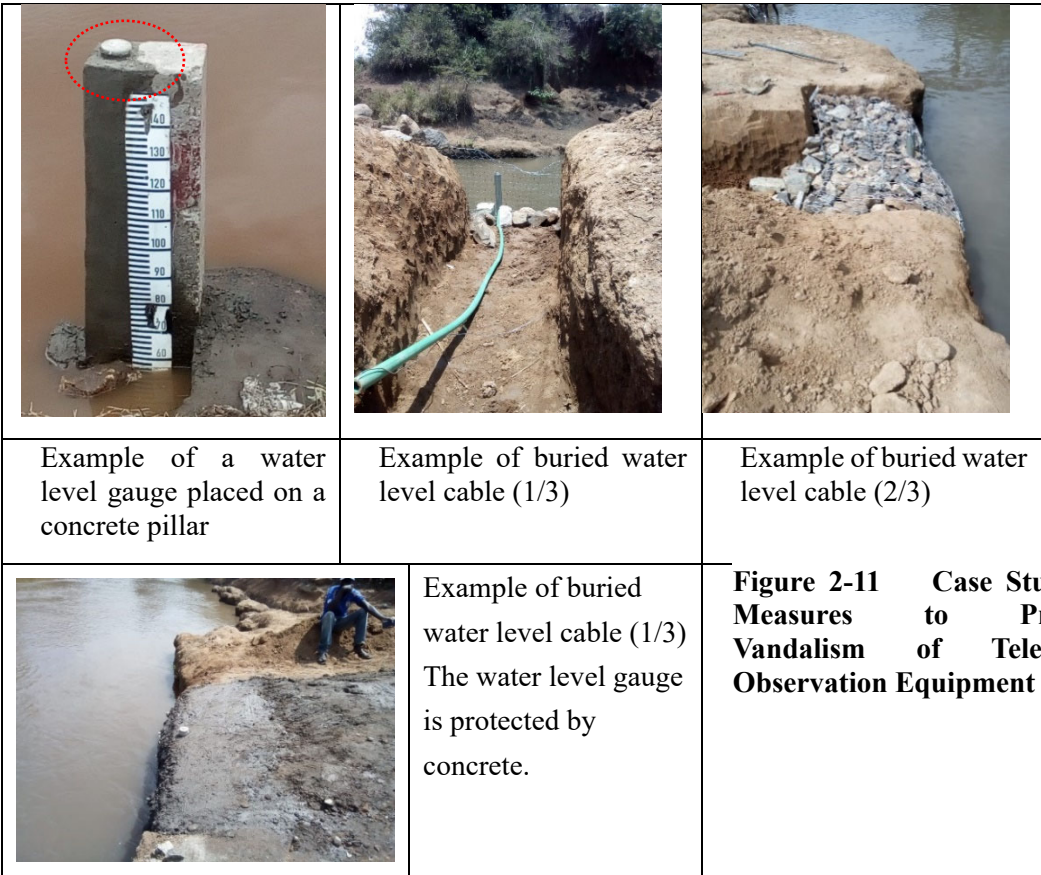


(Source: <https://www.nperf.com/en/map/KE/-/>)

Figure 2-10 Coverage Area of Telkom Network

(4) Measures Against Vandalism

As mentioned in Subsection 2.1.3 (1), acts of vandalism against the observatory have impacted its operation. According to an interview survey at the WRA Headquarters, WRA is working to protect the telemetry facilities by taking measures against vandalism, such as changing the material of the water gauge from steel to concrete and burying the cables. The following photos show the measures taken against vandalism.



(Source: JICA Expert Team)

2.2.2 (Activity 2.2) Support for the Preparation of an Operational Plan for Data Transmission Facilities

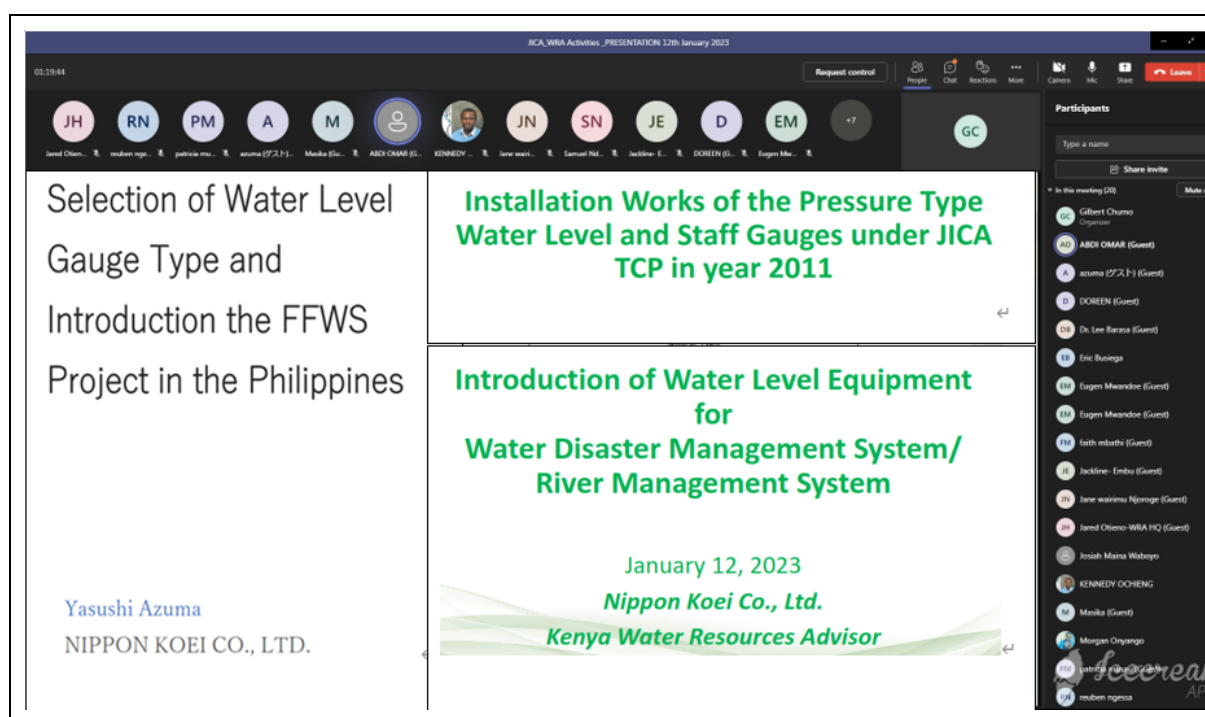
(1) Introduction of Equipment and Facilities through Case Studies of Existing Projects

After the fifth fieldwork, on January 12, 2023, an online lecture was held by an expert in charge of "Communications/Innovation Technology" to introduce case studies of meteorological and hydrological observation equipment. The lecture was held as part of support for formulating operational plans for meteorological and hydrological observation facilities and data transmission equipment.

The contents are as follows:

- Selection of Water Level Gauge Types and Introduction to the FFWS Case of the Philippines
- Introduction of Water Level Equipment for Water Disaster Management System/River Management System - Case of Flood Sensors (image type)
- Introduction of Pressure Type Water Level and Staff Gauges under JICA TCP Sensors in 2011

A total of 20 people participated in the lecture, including six from the WRA Headquarters, nine from the Basin Office and Sub-basin Office, and five from the JICA Expert Team. WRA staff requested that similar technology introduction lectures be held in the future. The three lecture materials are attached in Attachment 10.



(Source: JICA Expert Team)

Figure 2-12 Online Lecture Screen by "Communication/Innovation Technology" Expert

2.2.3 (Activity 2.3) Training on Observation Facilities and Data Transmission Facilities

During the ninth fieldwork, from July 24 to 26, 2024, an expert in charge of "Communication/Innovation Technology" conducted training on the equipment used for meteorological and hydrological monitoring and data transmission equipment with the WRA Headquarters staff in Embu, where the Tana Basin Office is located.

The "Communication/Innovation Technology" expert and the WRA Headquarters staff gave lectures on data transmission equipment in Kenya and Japan. A total of 37 people attended the three-day training, where they learned about the storage and analysis methods for meteorological and hydrological observation data through the operation of Mike Workbench and Mike Zero software owned by the WRA.

The training program and presentation materials are attached in Attachment 11.

2.2.4 (Activity 2.4) Reinforcing Capacity On-site Observations, including Preparation of H-Q Curves

(1) Observation Stations to be Targeted for Capacity Building

During the first and second fieldwork, the JICA Expert Team carried out discharge measurement and river cross-section surveys and inspected the monitoring stations targeted for future capacity-building activities. Taking into account the conditions at the monitoring points, the JICA Expert Team decided to carry out activities at the following three locations.

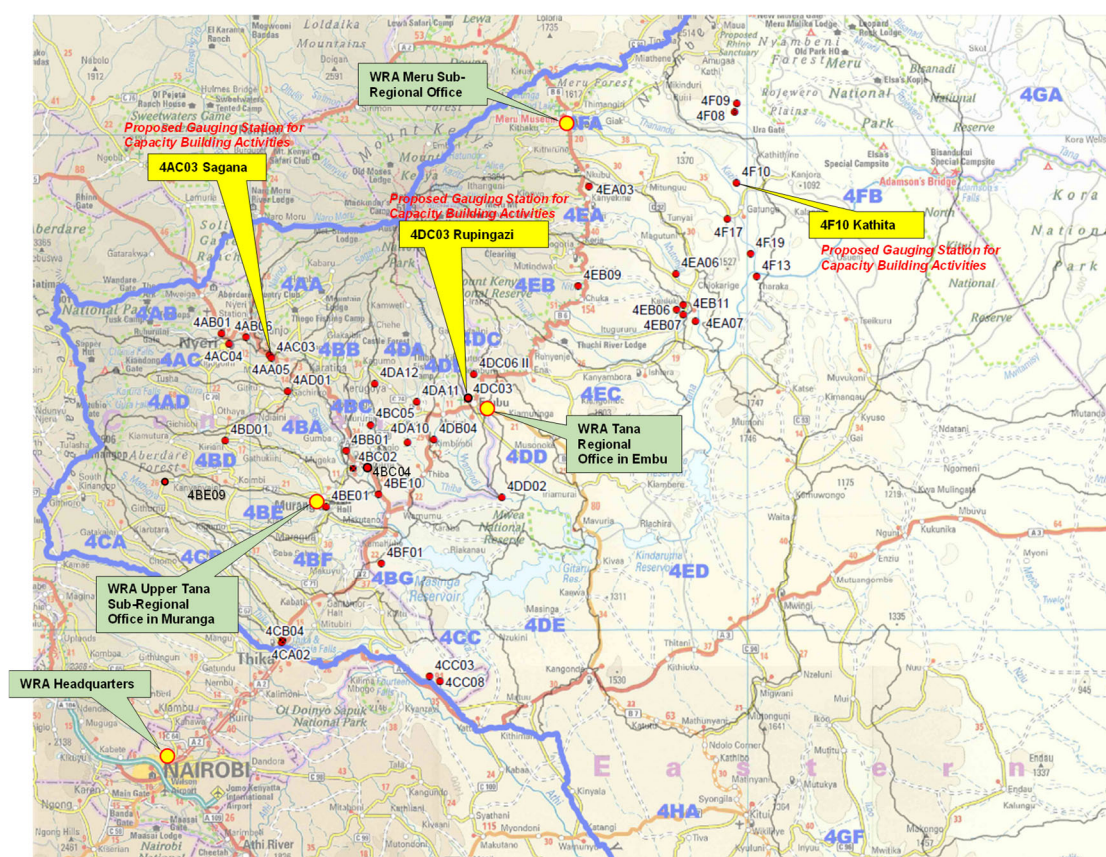
Table 2-6 Candidate Stations to be Targeted for Capacity Building (Before Change)

No.	Name of the Station	Name of the River	Status
4F10	Kathita	Kathita	The JICA Expert Team inspected the site on July 7, 2021. A water level indicator was installed at the foot of the bridge. Exposed rocks were visible on the riverbed, and it appears that there has been little change in the operational cross-section.
4DC03	Rupingazi	Rupingazi	The site was selected based on a report from the WRA staff. It is a natural river with no artificial structures, such as bridges.
4AC04	New Chania	Chania	The site was also observed and surveyed during the previous advisory work. It is worth comparing and evaluating what changes have occurred in the cross-section over the past four years.

(Source: JICA Expert Team)

However, during the third field survey, the water gauge for 4AC04 New Chania was damaged, and it was decided to consider another site since it was not expected that the WRA would be able to repair it. In March 2022, other candidate sites were inspected, and 4AC03 Sagana was selected as the new

observatory candidate site, with WRA's approval obtained. Of the three sites, the WRA was approached for implementation, approval was obtained for all.



(Source: JICA Expert Team)

Figure 2-13 Changed Observatory Candidate Site

Table 2-7 Candidate Stations to be Targeted for Capacity Building (After Change)

No.	Name of the Station	Name of the River	Status
4F10	Kathita	Kathita	The JICA Expert Team inspected the site on July 7, 2021. A water level indicator was installed at the foot of the bridge. Exposed rocks were visible on the riverbed, and it appears that there has been little change in the operational cross-section.
4DC03	Rupingazi	Rupingazi	The site was selected based on a report from the WRA staff. It is a natural river with no artificial structures such as bridges.
4AC03	Sagana	Sagana	Sites were inspected and selected based on reports from the WRA staff.

(Source: JICA Expert Team)

(2) Cancellation of Local Subcontracted Work

The JICA Expert Team was preparing specifications for local subcontracted work and a list of potential contractors to carry out flow observation and river cross-section survey according to the work plan. However, the WRA requested to take charge of the flow observation and river cross-section

survey, as they were capable of carrying out the work. For this reason, the JICA Expert Team explained to JICA that the procurement of a local subcontracted contractor, as originally planned, would be canceled, and that the WRA staff would carry out the flow observation and river cross-section survey themselves. This was approved.

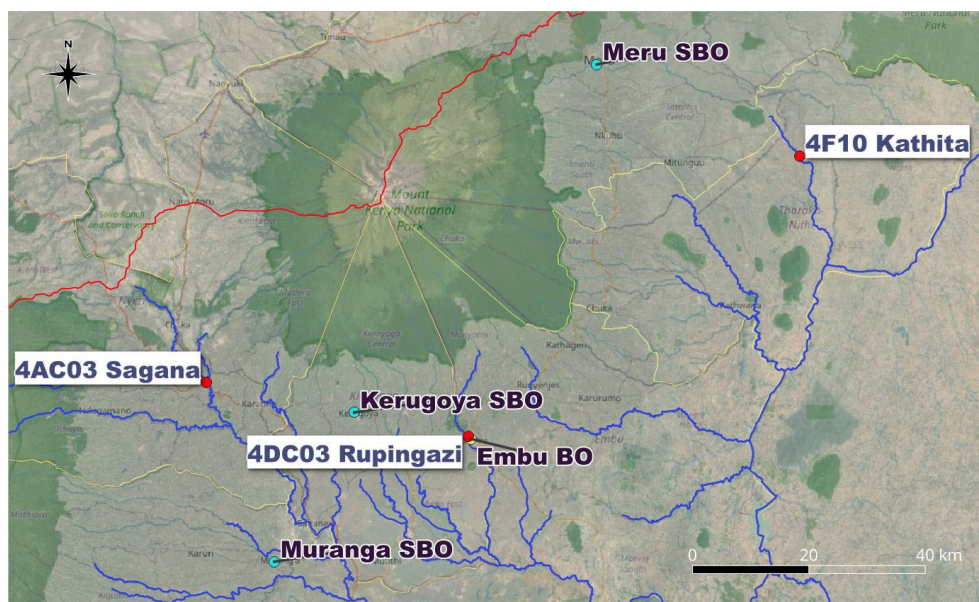
It was believed that the WRA staff would be in charge of the actual work, but in reality, the WRA only had one to three people, resulting in a shortage of personnel. At least four to five workers were needed for one observation station. Given that the JICA Expert Team had local assistants, the team decided to collaborate with them and proceed with the work.

The observation and survey work was carried out a total of four times, which was the originally planned number, according to the following schedule.

1st: March 2022
2nd: December 2022
3rd: May 2023
4th: February 2024 (*)

*The fourth observation and survey were attempted in November 2023, but due to high water levels and flow rates, the observation was not possible and was abandoned.

The above-mentioned four river cross-section surveys and flow rate observations were carried out at three points: 4AC03 Sagana, 4DC03 Rupingazi, and 4F10 Kathita. The locations of each point are shown on the map in Figure 2-14.



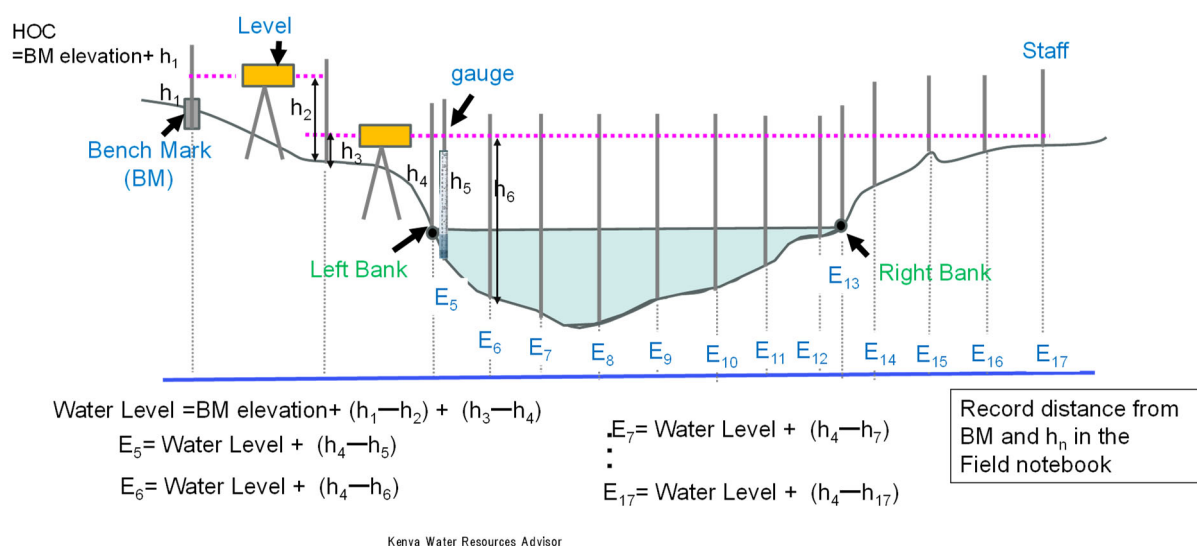
(Source: JICA Expert Team)

Figure 2-14 Location of Target Gauging Stations

(3) Method

1) Cross-Section Survey

Figure 2-15 shows the basic method for the cross-section survey. To accurately measure changes over time, it is necessary to survey the same line each time.

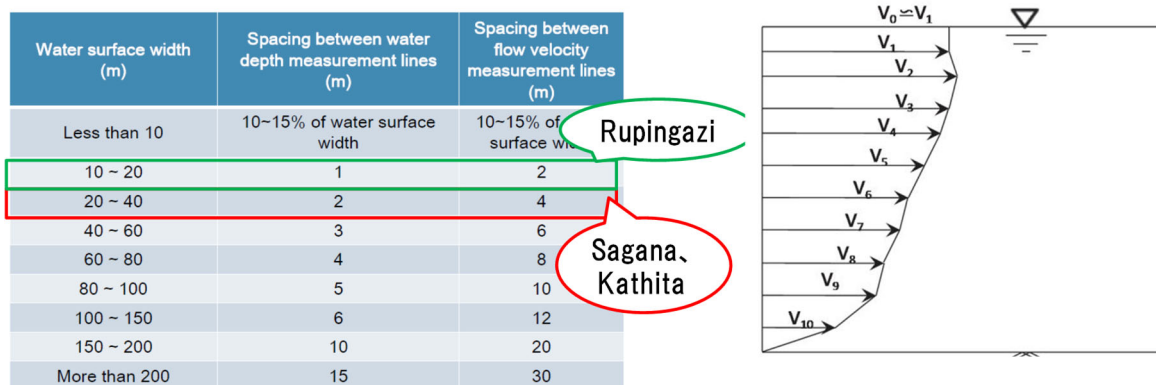


(Source: JICA Expert Team)

Figure 2-15 Schematic of Cross-section Survey

2) Discharge Measurement

Figure 2-16 shows the relationship between water surface width and spacing for water depth measurement lines applied in Japan. The JICA Expert Team recommended that the spacing between water depth measurement lines and flow velocity measurement lines should change depending on the water surface width.



Source: JICA Expert Team

Figure 2-16 Relationship between Water Surface Width and Spacing for Water Depth Measurement Lines

Regarding the measurement depth of flow, there are two methods. The normal method called the two-point method, measures the flow velocity at 20% and 80% of the water depth. The other method, called the one-point method, is usually applied when the water depth is less than 75 cm to one meter, and measures the flow velocity at 60% of the water depth.

3) Field Booking Sheet

Figure 2-17 is a sample of the field booking sheet for the cross-section survey and discharge measurement. It is difficult to calculate discharge at the RGS on-site. Therefore, the depth and flow velocity of each subsection are recorded in the field booking sheet.

Source: JICA Expert Team

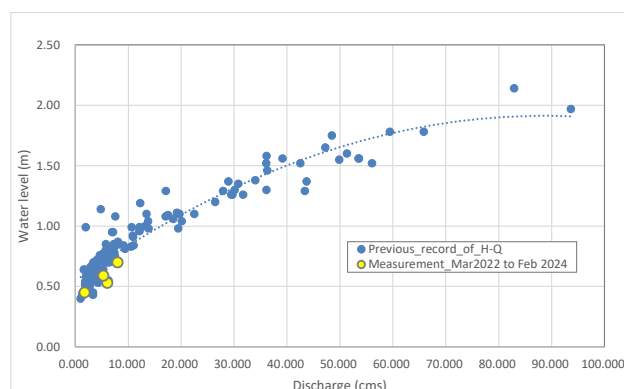
Figure 2-17 An Example of Field Booking Sheet for Cross-section Survey and Discharge Measurement

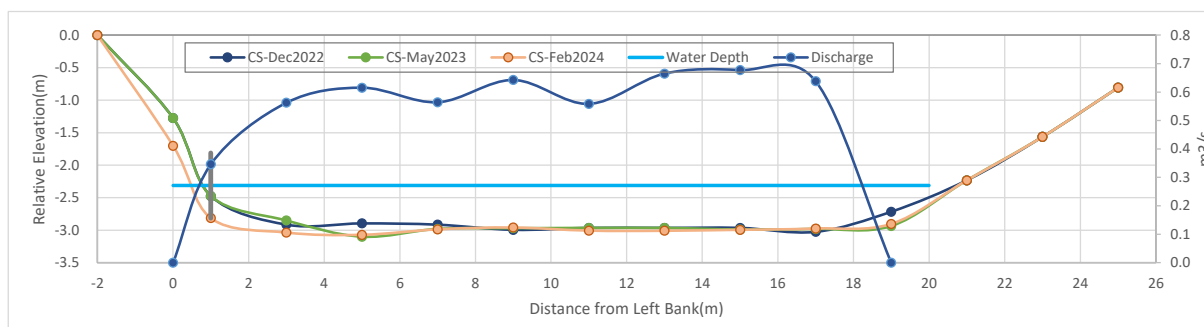
(1) Results of Site Works

1) 4AC03 Sagana

Four cross-section survey and discharge measurement results of 4AC03 Sagana are shown in Figure 2-18. Compared with the results prior to this activity, the discharge is higher for the same water level. This indicates that riverbed lowering has progressed more than in the past.

Date	Gauge height (m)	Discharge (m3/s)
29-Mar-2022	0.45	1.73
19-Dec-2022	0.53	6.02
23-May-2023	0.7	7.97
7-Feb-2024	0.59	5.27





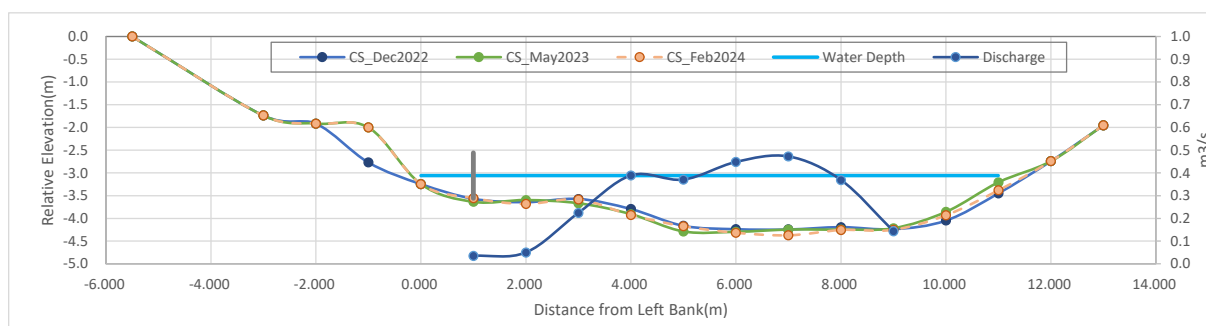
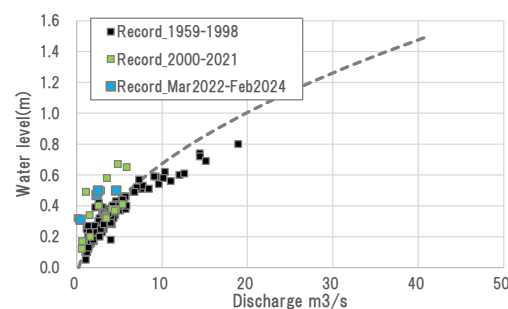
(Source: JICA Expert Team)

Figure 2-18 Cross-section Survey and Discharge Measurement Results of 4AC03 Sagana

2) 4DC03 Rupingazi

Four cross-section survey and discharge measurement results of 4DC03 Rupingazi are shown in Figure 2-19. Compared with the results prior to this activity, the discharge is lower for the same water level. This indicates that sedimentation in the riverbed has progressed more than in the past.

Date	Gauge height (m)	Discharge (m³/s)	Remarks
18-Mar-2022	0.31	0.425	
9-Dec-2022	0.47	2.34	1st Measurement 2.40 m³/s 2nd measurement 2.28 m³/s
23-May-2023	0.5	4.62	1st measurement 4.64 m³/s 2nd measurement 4.60 m³/s
8-Feb-2024	0.5	2.5	1st measurement 2.50 m³/s 2nd measurement 2.49 m³/s



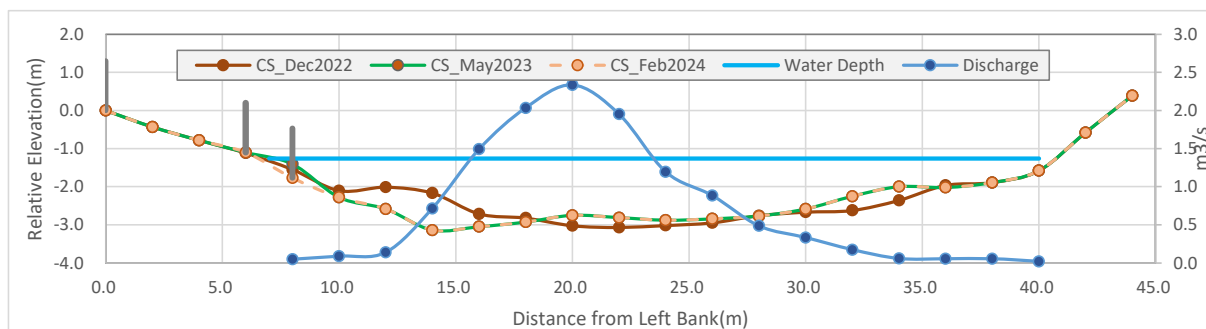
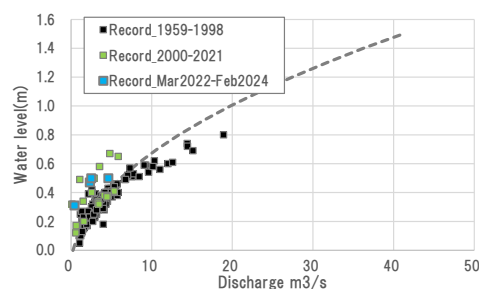
(Source: JICA Expert Team)

Figure 2-19 Cross-section Survey and Discharge Measurement Results of 4DC03 Rupingazi

3) 4F10 Kathita

Four cross-section survey and discharge measurement results of 4F10 Kathita are shown in Figure 2-20. Compared with the results prior to this activity, the discharge is lower for the same water level. This indicates that riverbed lowering has progressed more than in the past.

Date	Gauge height (m)	Discharge (m ³ /s)	Remarks
18-Mar-2022	0.31	0.425	
9-Dec-2022	0.47	2.34	1st Measurement 2.40 m ³ /s 2nd measurement 2.28 m ³ /s
23-May-2023	0.5	4.62	1st measurement 4.64 m ³ /s 2nd measurement 4.60 m ³ /s
8-Feb-2024	0.5	2.5	1st measurement 2.50 m ³ /s 2nd measurement 2.49 m ³ /s



(Source: JICA Expert Team)

Figure 2-20 Cross-Section Survey and Discharge Measurement Results of 4F10 Kathita

(2) Review Session

On February 14, 2024, the JICA Expert Team held a review session for discharge measurement and river cross-section surveys at the Tana Basin Office in Embu. The target was Surface Water Officers in the Tana basin offices (Kerugoya, Muranga, Embu, and Meru). Other officers from the regional office who were interested in participating in the session were also invited. The focus of the session included:

- Outline of Discharge Measurement Activities: Explanation of the purpose of the activities and an outline of survey and measurement activities.
- Method of Discharge Measurement: Explanation of the measurement methods, results of the survey, and measurement of activities.
- Explanation of Measured Discharge Calculation and Exercises: Explanation of calculation sheet exercises using MS Excel.
- Presentation on the Discharge Calculation Results.
- Discussion on Required Resources for Discharge Measurement and River Cross-section Survey.

The following are the key findings and challenges raised in the review session:

- Regularly monitoring the cross-sectional profile of all rivers is vital for updating rating curves more frequently, based on their constantly changing profiles. The Kathita River in 4F10 is particularly variable, which requires close monitoring along with other channels of the same kind.
- A field booking sheet that combines discharge measurement and cross-sectional profiles into one convenient form should be considered by the WRA. This could be beneficial for future comparison of the profiles at the regular gauging stations.

- Considering the number of RGSs that each sub-regional office is responsible for, the time required for the survey, the number of personnel required, and the equipment required, it became clear that there is a shortage of personnel and equipment. Regarding the shortage of personnel, there was an opinion that it is possible to get cooperation from WRUA.
- Participants requested the JICA Expert Team to provide an Acoustic Doppler Current Profiler, which can be utilized during floods.

For the explanatory materials and presentation materials at the result report session, please refer to Attachment 5, “Site Works Report” 20210214-A: Report on Review Session for Discharge Measurement and River Cross-section Survey Results.

2.3 Activities of Output 3

Activities of Output 3 are composed of the following two subjects:

Output 3 Capacity Building on Arrangement and Storage of Hydrological and Meteorological Data

Activity 3.1 Quality improvement guidance and preparation of quality control standards

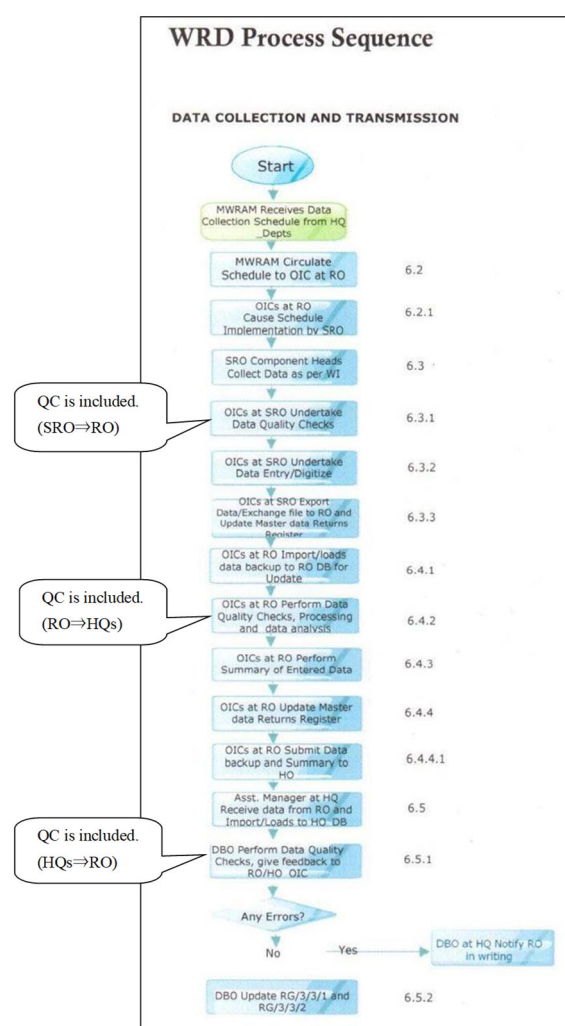
Activity 3.2 Confirmation of the current status and improvement of the operation and management of the database

Actual achievements for each item are as described below:

2.3.1 (Activity 3.1) Quality Improvement Guidance and Preparation of Quality Control Standards

(1) Current Procedure for Arrangement and Storage of Hydrological and Meteorological Data

Figure 2-21 shows the procedure of data transmission of the WRA. Several stages of quality checks are included in the procedure.



(Source: WRA-OPM-03-WRD-26 May, 2021)

Figure 2-21 Water Resources Data Process Sequence

According to the “Water Resources Monitoring and Processing, Process Number: PM-3-3,” RGS data are processed and transmitted to the following procedure:

(i) Upon receipt of water resources data from the gauge readers, the data forms receipt are registered in the sub-basin incoming mail register.

(ii) The sub-basin coordinators instruct the respective component heads to undertake data quality checks and forward the data collection forms to the OIC of data at the sub-basin area database.

(iii) The OIC of water resource data at the Sub-basin Area Office enters and digitalizes the water resources data returns into the Sub-basin Water Resources Information System and updates the Master Data Returns Register RG/3/3/1 within one week. The OIC of water resources data at the sub-basin area office also backs up the database on a monthly basis.

(iv) This OIC of water resources data at the Sub-basin Area Office downloads an exchange file after data entry, which is sent to the OIC of water resources data at the Basin Area Office via email for updating the Regional Water Resources Information System.

(v) The OIC of water resources data at the Basin Area Office downloads the exchange file from the email, performs data quality checks, and uploads it to the Basin Area Water Resources Information System.

(vi) In case of inconsistencies in the data received, the OIC raises a flag on this and notifies the officer in charge of water resources monitoring at the Basin Area Office.

(vii) Upon receipt of all the exchange files from all the sub-basin offices within the basin area, the OIC in charge of water resources data at the Basin Area Office downloads an exchange file from the Water Resources Information System and sends it to the AM-WRRC at the HQ. The OIC also updates the Master Data Return Register RG/3/3/1¹ and compiles the summary of data entered as per F/3/3/2².

(viii) Upon receipt of the exchange file from the Basin Area Office, the AM-WRRC restores the data to the National Water Resources Information System, updates the RG/3/3/1, and informs the respective component at the WRA HQ to access the Water Resources Information System, carry out data quality checks, and give feedback to the respective basin area offices.

¹ Master Data Returns Register

² WR Data Transmission Form

(ix) If data has been digitized and is in the basin area database, which could be old data not present in the database, proceed as outlined in step (vi).

(x) If the data has been digitized at the HQ, which could be old data not present in the database), the respective component heads should proceed as follows:

a) Perform data quality checks, processing, and analysis.

b) Forward the prepared time series data to the Regional Office for entry into the regional database.

c) Upon receipt of the time series data from the WRA Headquarters, the OIC at the Basin Area Office shall proceed as outlined in step (vi).

(2) Guidance on Improving the Quality of Meteorological and Hydrological Data and Preparation Quality Control Standards

Through the meeting, the JICA Expert Team discovered that the WRA does not have a specific method or standard for quality control. Instead, the WRA staff conduct quality control based on their experience and historical records.

Therefore, the JICA Expert Team proposed clarifying the items and criteria for a Quality Control Standard. Details are described in Appendix 12.

2.3.2 (Activity 3.2) Confirmation of the Current Status and Improvement of the Operation and Management of the Database

The “Guideline for Hydrometeorological Database Management” was developed in the previous JICA project. However, this guideline was not used by the WRA. Instead, the WRA uses PM-3-3: Water Resources Monitoring Data Process as introduced. The format of the Master Data Returns Register RG/3/3/1 is shown in Figure 2-22, and the format of FG/3/3/2 is shown in Figure 2-23.

However, this document does not describe how data management personnel flagged abnormal data or the actions taken when they received it. This is likely because the quality control criteria are not clearly defined. It is necessary to record how quality control and corrections were performed in the "Notes" of RG3/3/1 so that subsequent staff can understand the processing done in the previous data management.

	WATER RESOURCES AUTHORITY															
	TITLE: Master Data Returns Register										REF. NO: RG/3/3/1					
											ISSUE NO: 04					
	DEPARTMENT: TECHNICAL										REV. NO: 03					
	RECOMMENDED BY: TCM										DATE OF ISSUE: 11 th Feb, 2019					
AUTHORIZED BY: CEO										PAGE: 1 of 1						

S/No.	HQs/RO/SRO	Stn. ID	Station Name	Data Type (GWL, RF, WL, EV, Disch, WQ&PC)	Year.....												Remarks
					Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	

Recommended by:.....
Technical Coordination Manager

Approved by:
The Chief Executive Manager

(Source: WRA-OPM-03-WRD-26 May, 2021)

Figure 2-22 Format of the Master Data Returns Register: RG/3/3/1

	WATER RESOURCES AUTHORITY															
	TITLE: Water Resources Data submission form										REF. NO: F/3/3/2					
											ISSUE NO: 02					
	DEPARTMENT: TECHNICAL										REV. NO: 1					
	RECOMMENDED BY: TCM										DATE OF ISSUE: 11 TH February, 2019					
AUTHORIZED BY: CEO										PAGE: 1 of 1						

Backup ID: ----- (e.g. ENCA-28022019)

S/No.	Office (SRO, RO)	Stn. ID	Station Name	Entered data (GWL, RF, WL, EV, Disch, WQ&PC (pH, Turb, etc.), etc.)	Data Period

Recommended by:.....
Technical Coordination Manager

Approved by:
The Chief Executive Manager

(Source: WRA-OPM-03-WRD-26 May,2021)

Figure 2-23 Format of the Water Resources Data Submission Form: FG/3/3/2

2.4 Activities of Output 4

The activities of Output 4 are composed of the following five subjects:

Output 4 Capacity Building on Analysis and Utilization of Hydrological and Meteorological Data

- Activity 4.1 Guidance on basic analysis: implementation of flow regime arrangement/compilation and probabilistic analysis
- Activity 4.2 Analysis of the effects of climate change
- Activity 4.3 Discussion and compilation of the functions of WRA, as well as the utilization and analysis of monitoring results during droughts
- Activity 4.4 Discussion and compilation of measures to be taken during droughts, as well as the utilization and analysis of monitoring results
- Activity 4.5 Discussion and notification to related organizations on the hydrological and meteorological data

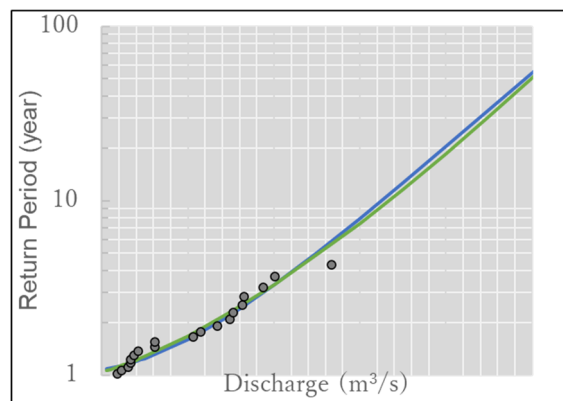
The actual achievements for each item are described below:

2.4.1 (Activity 4.1) Guidance on Basic Analysis: Implementation of Flow Regime Arrangement/Compilation and Probabilistic Analysis

This activity was carried out as a training session in June 2024 using Microsoft Excel. Participants recognized that frequency analysis is highly dependent on the results of daily monitoring. Through this exercise, participants learned the importance of daily monitoring, quality control, and data storage.



Guidance lecture in Embu on June 10, 2024
(Source: JICA Expert Team)



Example of frequency analysis of 4AC03 Sagana

Figure 2-24 Situation at the Time of the Training and Some of the Contents of the Training

Reports and materials from the training session are attached in Appendix 5.

2.4.2 (Activity 4.2) Analysis of the Effects of Climate Change

For this activity, the JICA Expert Team conducted lectures on “Analysis Flow of Climate Change” on October 13, 2023, and “Climate Variability” on June 10, 2024, respectively.

Regarding the lecture held on October 13, 2023, the workflow chart of climate change analysis using CMIP3 GCMs, methodologies adopted in the NWMP 2030, and results of climate change analysis in the NWMP 2030, among others, were introduced. The materials of the lecture are attached in Appendix 5.

With regard to the lecture held on June 10, 2024, the JICA Expert Team made a presentation on the mechanism of rainfall, climate variability around Eastern Africa, and projected future climate risk using some figures and the latest climate science articles. The materials of the lecture are attached to Appendix 5.

2.4.3 (Activity 4.3) Discussion and Compilation of the Functions of WRA, as well as the Utilization and Analysis of Monitoring Results during Droughts

The discussion with WRA for this activity revealed that the mandate of WRA is to focus on flood mitigation, with a focus on flood early warning to reduce the impacts of floods on vulnerable communities. However, the assessment of flood impacts is limited to water resources.

(1) The Way of Usage of Monitoring Data for Flood Damage Mitigation:

To date, the Tana Basin has experienced two floods consecutively: one from October to December 2023 and another from March to April 2024.

The WRA issues advisories about potential floods by monitoring river conditions and using forecasts from the Kenya Meteorological Department. In the Tana River basin, the Garissa Station 4G01 is used to track downstream floods. An "alert" status is declared when the water level reaches 3.5 m, while an "alarm" status is issued at 4.0 m. When an "alert" status is in effect, water spillage in some downstream areas of the Garissa station is expected. Rising water levels in the rivers and weather forecasts from KMD trigger communication. The telemetric station is checked hourly, allowing for timely status updates. The released advisory is valid for a specific period, e.g., two weeks.

(2) Challenges for Flood Advisories and the Monitoring System of WRA

It has been observed that the current station does not provide enough lead time for early flood warnings, particularly since Garissa town is also affected by floods. Therefore, it is necessary to install a station upstream of the Garissa Station 4G01 to improve the lead time for early flood warnings.

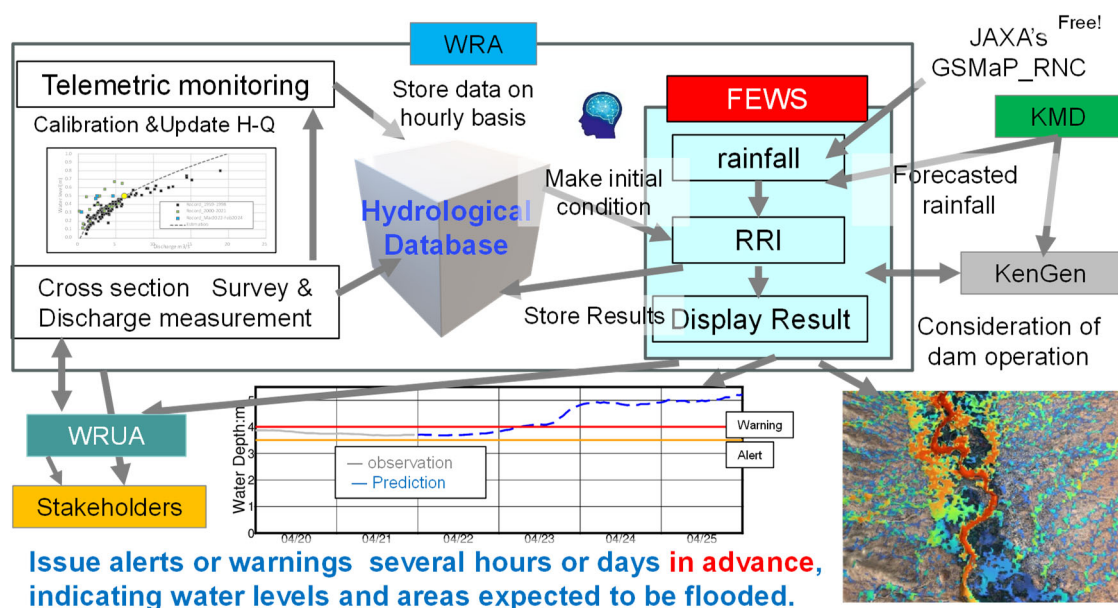
The advisory only provides general areas that are likely to be affected, without specifying the specific households that will be affected. There is a need to develop a model that can provide this specific information, which would be useful for the flood early warning system in the Tana River basin.

The seven Folk dams in the Tana Basin are crucial for reducing floods in the area. It is noted that the Mutonga-Kitui System significantly contributes to flooding in the lower Tana. Unfortunately, these areas have limited infrastructure to monitor flows, especially from the Kitui and Garissa sub-basins. This poses a serious shortcoming in flood mitigation in the lower Tana basin.

The WRA uses the formally laid-down procedure to issue flood advisories to stakeholders. The KMD, gauge readers, and KenGen are essential stakeholders in data collection, which forms the basis for the release of flood advisories.

(3) Proposal to Solve the Challenges

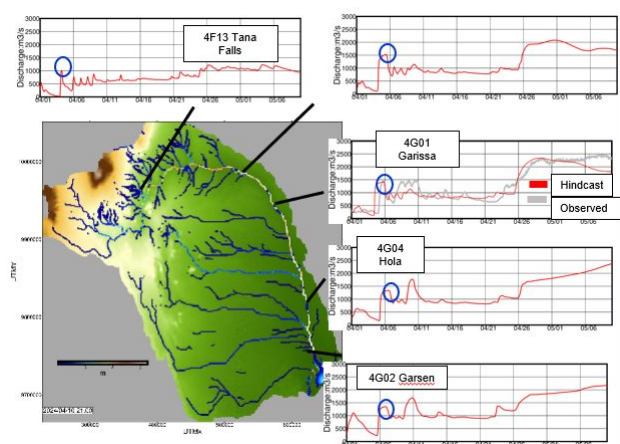
The JICA Expert Team proposed that instead of installing flood alert stations upstream of Garissa, a flood early warning system based on rainfall forecast information and runoff and inundation analysis models should be used to issue an alert and/or alarm before flooding occurs. A schematic diagram is shown in Figure 2-25.



(Source: JICA Expert Team)

Figure 2-25 Schematic Image of Proposed Flood Early Warning System and Collaboration with Related Organizations

After preparing the Tana River basin prototype, training was conducted at the WRA Headquarters on September 12, 2024. During the training, the information that residents would expect from WRA in the event of a flood, such as flood depth and duration, was discussed. The JICA Expert Team informed them that the model can output such information.



One of the outputs for the training

(Source: JICA Expert Team)



Discussion in the training

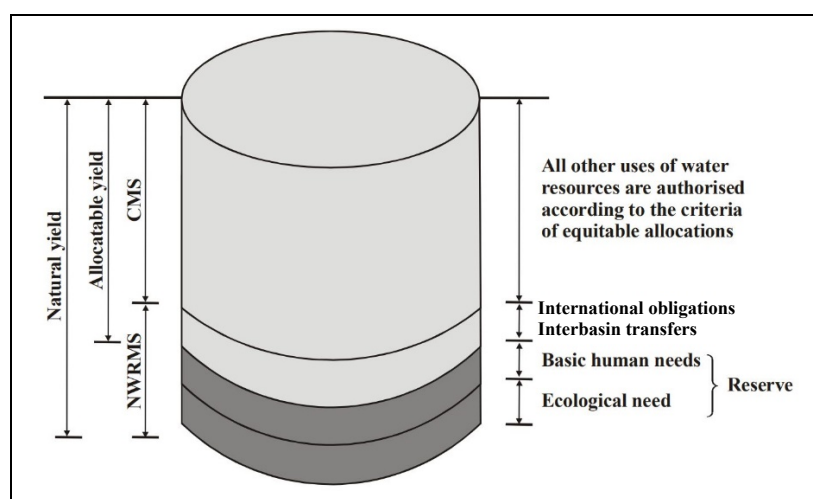
Figure 2-26 Training on the RRI Model for the Tana Basin

2.4.4 (Activity 4.4) Discussion and Compilation of Measures to be Taken During Droughts, as well as the Utilization and Analysis of Monitoring Results

(1) General Concepts of Water Allocation

The allocation of water from a water body should take into consideration **four** demands on the water, namely:

1. The portion of the water resource required to meet ecological demands, forms part of the **Reserve**.
2. The portion required to meet basic human needs, forms the other part of the **Reserve** as defined in the WRM rules.
3. The portion of water for which commitments have been made in international treaties and inter-basin water transfers.
4. The portion of water that can be allocated to individual uses by means of a permit.



(Source: Water Allocation Guideline in Kenya)

Figure 2-27 Conceptual Graph of Water Allocation in Kenya

The water balance can be summarized as follows:

$$\text{Water Balance} = \text{Available Water} - (\text{Reserve} + \text{Transfers} + \text{Summation of All Water Allocations})$$

A positive water balance implies that the resource is sufficient to meet all the water demands. A negative water balance implies that the resource is insufficient to meet all the water demands.

Where there is insufficient resource to meet all demands, in addition to verifying that the correct quantities of water have been applied for, the Authority shall apply one of the following approaches:

- a. Prioritization
- b. Reallocation and Proportional Allocation

a) Prioritization

- It is important to reinforce that the priority for water resources is the **reserve**. With respect to the portion of water that can be allocated to specific users, domestic water has a higher priority than other uses (Water Act 2002, Section 32(2)).

b) Reallocation and proportional allocation

- Sections 35 and 36 of the Water Act 2002 provide the basis for the reallocation and proportional allocation of the resource. Essentially, these sections provide the Authority with the powers to review, amend, or cancel a permit or permits where there is reasonable cause, in order to promote sustainability, equity, public beneficial interests, efficiency, and to protect water resource quality.

(2) Actual Situation for Drought Responses

The JICA Expert Team made interviews with the Embu Basin Office and the Muranga Sub-basin Office.

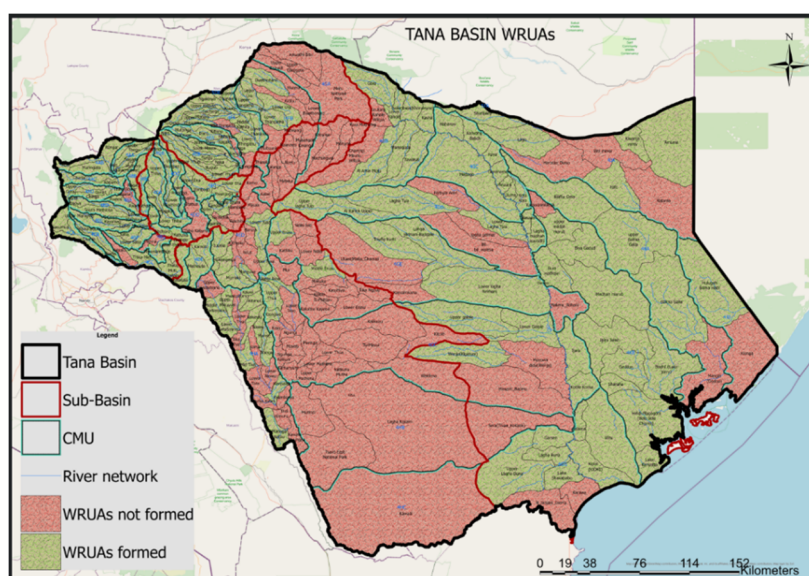
1) Information Provided by Embu Regional Office

a) Utilization of Hydrological Monitoring Results

- The WRA undertakes low-flow measurements periodically to establish the lowest flows regularly. This information is useful in determining the sharing of water during drought seasons. The Q95 index is used to determine the reserve flows according to the Water Act 2016. Low-flow analysis is not used as the basis for determining the frequency of the lowest flows in the rivers. Daily monitoring data are used to determine the Q95 flow index.

b) Coordination with Stakeholders

- The WRA, WRUAs, and other stakeholders undertake inspections of water works to check conformity to the permit conditions.
- The WRUAs have been formed in several sub-basins, and sub-catchment management plans (SCMPs) are developed in cooperation with the WRUAs and other stakeholders.



(Source: WRA)

Figure 2-28 Areas WRUAs Formed

Table 2-8 Situation of Formation of WRUA and Development of SCMPs in the Tana Basin

Sub-basin Area	No. of Formation of WRUA	No. of Development of SCMPs
Upper Tana	34	33
Kathita Mutonga	30	30
Thiba	21	17
Tiva Tyaa	28	20
Lower Tana	81	34
Totals	194	134

(Source: WRA)

- Based on SCMPs, the community implements various infrastructure projects, such as the installation of rainwater harvesting and storage tanks, the construction of sand dams, tree nurseries, and spring protection and development, among others.
- During droughts, the community (WRUAs and abstractors) in a sub-basin usually meets to agree on water-sharing schedules. The agreements are enforced by a multi-agency team that includes the WRA, police unit, local administration, and the community.

c) Challenges for Water Allocation

- Water use conflicts occurred, especially in the Ragati and Thiba sub-catchments, due to the shortage of water.
- Generally, the WRA has not undertaken an evaluation to determine water allocation levels in the rivers vis-a-vis the available flows and, hence, the balance for allocation. This is expected to be accomplished through water abstraction surveys that inform water allocation planning.

(3) Information Provided by Water Rights Office of Muranga Sub-regional Office

a) Drought Response and Role of WRA

- The officer noted that the office undertakes water abstraction rationing during the drought season, depending on the sub-basin affected.
- The office formally writes to the WRUAs concerned to sensitize them on the water situation and the need for a rationing program.
- A meeting is held among the stakeholders to develop a rationing schedule, which is shared with the local chief for enforcement. The team uses the Q95 index as the basis for rationing.
- Interventions include the suspension of abstraction for irrigation and industrial uses while giving prominence to domestic use, as stipulated in the Water Allocation Guidelines.
- The WRA is responsible for enforcing the reached agreements and the permit conditions.

b) Mitigation Measures

- Irrigation water users are encouraged to have a 90-day storage harvest during flood flows.

2.4.5 (Activity 4.5) Discussion and Notification to Related Organizations on the Hydrological and Meteorological Data

In September 2024, seminars were held in Embu, where the Tana Basin Office is located, and in Nairobi. The Embu seminar invited mainly stakeholders from the Tana River basin, while the Nairobi seminar invited national-level organizations and stakeholders. The participants and program of the seminars are shown in the following tables.

Table 2-9 Participants of the Seminar in Embu

SEMINAR IN EMBU	
Venue/Date	Embu- Izaak Walton Hotel September 17th 2024
Purpose	Dissemination of information sharing methods to assumed users of monitoring data and analysis.
Invited Participants	1) WRA: Water Resources Authority 2) JICA: Japan International Cooperation Agency, including the JICA Expert Team 3) Kenya Meteorological Department (County Directors) 4) County Governments (Kirinyaga, Meru, Embu, Muranga, Tharaka-Nithi, Kitui, Garissa) 5) Blue Deal Programme 6) WRA Region and Sub-region (Embu, Kerugoya, Meru, Muranga, Kitui, Garissa) 7) Kenya Red Cross Regional Office 8) Del Monte 9) NIA: National Irrigation Authority Regional Office 10) WRUA (Two Representatives) 11) County Commissioner

(Source: JICA Expert Team)

Table 2-10 Participants of the Seminar in Nairobi

SEMINAR IN NAIROBI	
Venue/Date	Nairobi - Fairview Hotel September 19, 2024
Purpose	Dissemination of information sharing methods to assumed users of monitoring data and analysis.
Participants	1) MWSI: Ministry of Water, Sanitation & Irrigation – Water, Irrigation Secretary 2) WRA: Water Resources Authority 3) JICA: Japan International Cooperation Agency, including the JICA Expert Team 4) KMD: Kenya Meteorological Department 5) NIA: National Irrigation Authority 6) HSK: Hydrological Society of Kenya 7) ACEK: Association of Consulting Engineers of Kenya 8) KSA: Kenya Space Agency 9) Blue Deal Programme 10) Kenya Red Cross: Kenya Red Cross Society, Nairobi 11) NDMA: National Drought Management Authority 12) NDOC: National Disaster Operations Centre 13) KEWI: Kenya Water Institute 14) AWWDA: Athi Waterworks Development Agency 15) KenGen: Kenya Electricity Generating Company

(Source: JICA Expert Team)

Table 2-11 Seminar Program in Embu and in Nairobi

Time	Activity	Speaker/Facilitator	Venue
08:30 - 09:00	Registration	JICA Expert Team/WRA	Hotel Lobby
09:00 - 09:15	Opening Remarks and Introduction	WRA - Chief Executive Officer (CEO)	Main Hall
09:15 - 09:25	Opening Remarks	JICA Representative	Main Hall
09:25 - 09:45	Introduction of WRA's Work	WRA – Manager Water Resources Assessment and Monitoring (M-WRAM)	Main Hall
9:45 - 10:00	WRA's Work in Tana and JICA Expert WRA Joint Activities	WRA – Tana Basin Area Coordinator	Main Hall
10:00 - 10:30	Introduction of JICA Expert WRA Activities incl. Q&A	Team Leader of JICA Expert Team Mr. Okamura	Main Hall
10:30 – 11:15	Tea/Coffee Break		Lobby
11:15 -12:00	Hydrological Monitoring and Data Management incl. Q&A	JICA Expert Team Mr. Okada/ Dr. Masika	Main Hall
12:00 - 12:45	Real Time Telemetric Data Acquisition and Applications – Tana Basin and New Technology incl. Q&A	JICA Expert Team Mr. Azuma/ Mr. Eugene	Main Hall
12:45 - 14:00	Lunch Break		Dining Area
14:00 - 14:30	Introduction of FEWS and RRI	JICA Expert Team Mr. Okada/Dr. Masika	Main Hall
14:30 - 15:15	Interactive Session Q&A - Identifying Issues and Opportunities	WRA and Key Stakeholders	Main Hall
15:15 - 15:45	Tea/Coffee Break		Lobby
15:45 - 16:00	Closing Remarks and Way Forward	WRA, JICA Expert Team	Main Hall

(Source: JICA Expert Team)

As for the detailed information on the seminars and achievements, it is provided in Attachment 6, “A Report on Publication Seminars in Embu and in Nairobi.”

	
Presentation by “Communication/ Innovation Technology” expert in Embu	A group photo of participants of the seminar in Embu
	
Participants of the seminar in Nairobi	A group photo of participants of the seminar in Nairobi

2.5 Common Activities in All Outputs

2.5.1 Equipment to be Delivered to WRA

The equipment procured through this project is shown in the table below. All equipment has been handed over to WRA as of the end of October. Photographs of the equipment are shown in Attachment 18.

Table 2-12 Equipment/Items to be Delivered to WRA

NO	ITEM/EQUIPMENT	QUANTITY	MODEL	BRAND NAME	COLOUR	SERIAL NO
1	LCD Projector	1	H973D	EPSON EB-W06	White	X89C1500418
2	Digital camera	1	R02050	RICOH WG-6	Orange	YQ10116781
3	Color Printer	1	M283fwd	HP Laserjet pro MFP	White	VNBRP4TOWT
4	WIFI Router	1	AK3300	ADRIAN	White	SCOM0026462AK
5	WIFI Pocket Routers	3	E5576-856 (Safaricom 90BA)	HUAWEI	White	FUC7S21419000356
			E5576-856 (Safaricom 90AE)	HUAWEI	White	FUC7521419000353
			MW41CL	ALCATEL	Black	4894461482415
6	Note PC	2	440 G9	HP ProBook	Grey	SN5CD229FD1F
			440 G9	HP ProBook	Grey	SN5CD229FD2B
7	27" PC Monitor	1	M27f	HP	Grey	3CM234144S
8	VOIP Conference Speaker & microphone	1	USB-SPPHLI	I-O DATA	Black	134K004048UR
9	Waterproof Wader suits	3	PVC	Decathlon Caperlan	Olive green	003499611874
			PVC	Decathlon Caperlan	Olive green	003500176453
			PVC		Black	
10	Aluminium level staff	1	ALG-25Y	MYZOX (2M 5 Section)	Yellow - White	4938514214957
11	Anchorage rope(50M)	1		Manilla	White	

(Source: JICA Expert Team)

2.5.2 Newsletter

As part of the public relations activities, a total of 11 newsletters, each A4 size with two to three pages, were prepared and posted on notice boards at the WRA Headquarters, the Tana Basin Office in Embu, and each Sub-basin Office. This allows project information to be made available to WRA stakeholders. The publication dates and main contents of the newsletters are as follows and are summarized in Attachment 1.

Table 2-13 Outlines of Newsletters

Issue No.	Year/Month	Contents
No. 1	2021/07	Project overview, objectives, results, implementation period, target areas, activities, field survey results, future plans, etc.
No. 2	Missing Number	-
No. 3	2022/04	Overview of activities, list of counterparts, planned flow observation locations, flow observation schedule, first river cross-section survey and flow observation, etc.
No. 4	2022/06	Overview of activities, visit reports to basin district offices, basin branch offices (Muranga, Kerugoya, and Meru) and related observation sites.
No. 5	2022/12	Overview of activities, river cross-section surveys and flow observations, progress of major activities related to each outcome, progress of flow observations (subcontracted locally), future activity plans, etc.
No. 6	2023/01	Overview of activities, lecture by "Communication/Innovation Technology" Expert on telemetry observation equipment, and introduction of application examples, etc.
No. 7	2023/05	Overview of activities, visits to the basin district office and basin branch offices (Muranga, Kerugoya, Meru) to understand the current water level observation situation and problems. Report on the third river crossing survey and flow observation work, and results, etc.
No. 8	2023/11	Overview of activities, report on capacity-building activities at the Tana Basin District Office from October 12th to 13th, results of the fourth river crossing survey and flow observation trial (abandoned due to high water level and large flow), report on inspection of other observation facilities, etc.
No. 9	2024/02	Overview of activities, the fourth river cross-section survey and flow observation (retry results) held on February 7-9, and the holding of a seminar to review all four surveys and observation operations.
No. 10	2024/06	Overview of activities, discussions with KMD held in June, capacity-building activities for data analysis at the Embu Watershed Office.
No. 11	2024/07	Overview of activities, lecture by Higashi Expert held in July on how to use telemetry observation equipment, lecture on Mike Workbench.
No. 12	2024/09	Overview of activities, report on seminars held in Embu and Nairobi in September

(Source: JICA Expert Team)

3 Issues, Solutions, and Lessons Learned in Project Implementation and Management

The following describes the challenges faced during the project, the solutions applied, and the lessons learned.

3.1 Challenges in Project Management

3.1.1 Gap between the Requested Contents and the Expert Dispatch Scheme

(1) [Issues] Comments from the WRA President from June to July 2021

The JICA Expert Team met with the Chief Executive Officer (CEO) of the Water Resources Authority (WRA), on June 24, 2021, to explain the outline of the work. At that time, there seemed to be a slight gap between the work content explained and the WRA's understanding. In addition, when the JICA Expert Team met with the CEO on July 14, 2021, to explain the results of the on-site inspection, the team received several opinions. The main ones are as follows:

- ◆ At the time of the meeting on June 24, 2021:
 - Technical cooperation was requested in the request dated August 15, 2019, but experts were ultimately dispatched. If JICA has any information on the technical cooperation project and the dispatch of experts, such as the type of work and definition, the WRA would like to have it.
 - The team is unable to go to Garissa and its downstream areas due to security issues. However, Garissa and its downstream areas are the most affected by flood damage. The WRA hopes that activities in the relevant area (Garissa and downstream areas) will be carried out by utilizing resources such as WRA staff and local consultants (hired personnel) who are planned to be hired.
 - While capacity building seems to be the main focus, the WRA is currently promoting telemetering of the monitoring stations. Therefore, WRA would like JICA to also consider providing monitoring equipment, etc.
- ◆ At the time of the interview on July 14, 2021:
 - The WRA is promoting telemetry at observation stations, aiming to establish a system in which measured water levels are immediately sent to the WRA Headquarters, rather than relying on the installation and collection of data loggers.
 - As water quality is also a serious problem, the JICA Expert Team would like to monitor water quality in real-time through telemetry.
 - The WRA is interested in understanding the budget available through JICA and how it will be allocated, as well as its clear presentation. The JICA Expert Team requests that care be taken to ensure that the purpose is thoroughly achieved through the process of procuring the necessary equipment, installation, and training. Even if it is just one location, the JICA Expert Team would like to ensure that it is implemented.

There seems to be room for consideration regarding the above requirements that can be met (as of the end of July 2021).

(2) [Ideas] Consultation with JICA and Holding of Joint Meeting (February 2, 2023)

After receiving comments from the WRA CEO, the JICA Expert Team consulted with JICA Headquarters and received a response that JICA's stance was to dispatch experts specializing in technology transfer, rather than providing observation equipment. For this reason, the JICA Expert Team continued their work steadily based on the work plan that reflected the special specifications.

A discussion was held at the JICA Headquarters on the current situation, problems, and solutions on December 26, 2022, before the sixth fieldwork trip scheduled for January-February 2023. After that, the JICA expert in charge of "Team Leader/Water Resources Management" traveled on January 16, 2023, and reported to the JICA Kenya Office on January 18. After receiving the report, the JICA Kenya Office requested a meeting with the WRA CEO. The meeting with the WRA CEO took place on February 2, 2023, and was attended by the JICA Kenya Office, WRA, and the JICA Expert Team. The following points were confirmed:

◆ Confirmation from the WRA CEO

- The Kenyan side requested a technical cooperation project; however, there are no signed project documents. Additionally, there are no work plans or progress reports. It appears that no coordination has been made with the higher-level agency, the MWSI.
- The WRA believes that it is necessary to coordinate and report to the Director of Water Resources and Japan Desk staff at the higher-level agency, the MWSI.

◆ Response from the JICA Kenya Office

- In response to the request for this technical cooperation project, JICA has notified the Kenyan side that it will dispatch experts.
- In the case of a scheme to dispatch experts, no records of discussions will be prepared for the scheme.
- Regarding discussions with MWSI, since the Director of Water Resources is on vacation, the WRA and the JICA Kenya Office will coordinate a meeting with the ministry two weeks after the vacation ends.

◆ Request from the WRA Technical Manager

A request has been made for advice from a telemetering expert on the operation of WRA's communication equipment. Specifically, it appeared that the request was for a system assessment of smart meters and telemetering.

The JICA Kenya Office asked WRA to prepare a one to two-page Clarity Paper and submit it to the JICA Kenya Office regarding the above request. As of October 2024, this Clarity Paper has not yet been submitted.

As a result of the above coordination meeting, a letter of approval for the dispatch of experts from MWSI was sent to the WRA CEO on April 17, 2023. After about two years since the start of the activities, the experts' activities have finally been officially approved.

For the minutes of the coordination meeting, refer to Attachment 13, "Coordination Meeting between WRA, JICA Kenya Office, and the JICA Expert Team (February 2, 2023)", and Attachment 14, "An Official Letter from the Ministry of Water, Sanitation and Irrigation (MWSI) to the Water Resources Authority (WRA) regarding the acceptance of JICA experts (dated April 17, 2023)," for the letter of approval for the dispatch of experts from MWSI.

(3) [Lessons Learned] Cultivating a Common Understanding with WRA Regarding the Content of Activities

As for the gap between WRA and the JICA Expert Team regarding the content of activities, the JICA Expert Team believes it is important to take more time at the start of the work to confirm procedures between the two countries. Additionally, thorough alignment with JICA and WRA on the specific content, duration, and results of the activities is crucial for successfully carrying out long-term expert activities.

3.1.2 Extremely Busy Water Resources Authority (WRA) Executives

(1) [Challenge] Difficulty in Arranging Interviews with WRA Executives for Reporting and Making Decisions

During the first on-site operation, dated late June to early July 2021, the JICA Expert Team requested interviews and meetings with the CEO and Technical Manager. However, both were extremely busy, making it difficult to arrange the interviews. In Kenya, the fiscal year ends in June and the new fiscal year begins in July. For this reason, the JICA Expert Team learned that it is better to avoid traveling during this transitional period, and made arrangements for subsequent investigations. Even outside these periods, it was extremely difficult to obtain appointments for interviews with the CEO and Technical Manager of WRA.

(2) [Measures] Interviews with the Technical Manager, Early Morning Appointments, Extension of the Dispatch Period of Japanese Staff, Compensation through Online Correspondence, Follow-up by Hired National Assistant Staff

If it was difficult to meet with the CEO, the JICA Expert Team requested an interview with the Technical Manager and secured a time when the Technical Manager is available, such as 7:00 a.m. before work hours, to conduct interviews and reports.

In addition, since the cancellation of the river cross-section survey and flow rate observation work, which was a local subcontracted work, the JICA Expert Team used the budget to extend the dispatch period of Japanese experts as much as possible and took care to obtain sufficient responses from the WRA side. The JICA Expert Team also devised ways to respond after leaving the site, such as holding online lectures.

If it still took time to obtain information or feedback, the JICA Expert Team enlisted the assistance of locally hired staff to follow up and devise ways to obtain information and responses.

(3) [Lessons Learned] JICA Experts Should Respond with a Sense of Urgency

As mentioned above, the WRA's busy schedules often made it difficult to secure time for meetings. It seems that communication could be made smoother by extending the period of dispatch of JICA experts. In addition, it is also effective to utilize early morning hours, supplementing online communication, and utilizing follow-ups by local staff. It is essential to prepare a variety of options and continue with the ones that yield the most favorable response.

3.1.3 Delay in Counterpart Placement, Personnel Transfers and Aged Counterparts

(1) [Issues]

This relates to the busy situation of the senior officials mentioned in Section 3.1.2. The delayed placement of counterpart staff further impeded the progress of expert work, including fieldwork. The COVID-19

pandemic exacerbated the situation, as WRA staff were present in the office only about twice a week, hindering timely inquiries and communication. It was only in December 2021 that a technical focal person was appointed at the WRA Headquarters, and the placement of counterpart staff was also finalized. Full-scale work with counterparts began from the third fieldwork in mid-February 2022.

Of the nine nominated counterparts, four were over 55 years old, with one retiring in December 2023.

In terms of experienced surface water personnel, many counterparts were skilled in handling surveying and observation equipment, which the JICA Expert Team found reliable. However, it seems necessary to hire young surface water officers to strengthen their capabilities, in order to train the next generation. Although the WRA reportedly considered inviting personnel from other basin districts to participate in the activities of this project in order to strengthen their capacities, they were unable to coordinate the budget and timing for such dispatch, and this did not come to fruition.

In addition, the Technical Focal Person was also serving in the World Bank's KWSCR project, which limited his participation in this project.

One of the prerequisites for the project was that no personnel changes would occur among counterparts during the project period. However, personnel changes occurred in the Tana River basin area in January 2023, resulting in the replacement of both the Tana Basin Area Manager and the Basin Office Technical Manager.

(2) [Measures] Continuous Explanation of Activity Content, Communication Using Hired Personnel

There were some changes in counterparts due to personnel transfers. However, each time, presentation materials were used to explain the experts' activities, ensuring continuous follow-ups. Fortunately, there were no major personnel changes among the surface water officers (SWOs) who were mainly in charge of the work. Therefore, capacity-building activities were carried out relatively smoothly. Regarding the limited participation of the technical focal person from the WRA Headquarters, the secretary of the JICA Expert Team and locally hired personnel facilitated communication between the WRA Headquarters, the Tana Basin Office, and the Sub-basin Office, enabling activities to be carried out smoothly.

(3) [Lessons Learned] Strengthening Communication with the Basin Offices and Sub-basin Offices from the Early Stages

In order to achieve one of the main objectives of the capacity building activities – "improving and establishing the ability to observe, organize, accumulate, and analyze data" – the JICA Expert Team sought support from the counterparts, namely, the SWOs of the basin offices and sub-basin offices. This included accompanying the JICA Expert Team on field visits, since the first field survey. The JICA Expert Team believes that by collaborating closely, the capabilities of the counterparts were understood at an early stage leading to the efficient and smooth execution of subsequent work.

Although there were personnel changes in the basin district, the SWOs remained consistent throughout the work period. Therefore, the JICA Expert Team believed that a significant contribution to improving their capabilities in the aforementioned objective of "observing, arranging, accumulating, and analyzing were realized."

3.1.4 Cancellation of the Local Subcontracted Work "River Cross-section Survey and Discharge Measurement Works"

(1) [Issue] Cancellation of Local Subcontracting and Securing Necessary Human Resources

The "river cross-section survey and discharge measurement work" that the JICA Expert Team originally planned to carry out by signing a contract with a subcontracted company, was instead carried out by the WRA staff at the request of the WRA. However, there were not enough surface water personnel in the basin offices and sub-basin offices, raising concerns about the lack of resources needed to engage in the survey and measurement work.

(2) [Measures] Support from Staff in Other Fields at the Basin Branch Offices, Utilization of Locally Hired Personnel, Active Support for Work by Japanese Experts

As the river-cross section survey and discharge measurement work were carried out mainly by the three sub-basin offices – Muranga, Kerugoya, and Meru – other experts from the sub-basin offices (IT engineers, water quality personnel, water rights personnel, interns) were arranged to join the effort. When the sub-basin offices lacked sufficient resources, they sought support from the Embu Basin Office. Additionally, the secretaries and hired personnel of the JICA Expert Team participated as workers and the Japanese experts shared the work as necessary.

(3) [Lessons Learned] Conduct Work in a Flexible Team or Outsource

Surveying and observation work can be performed if one knows how to use the equipment, how it moves in the river, and the procedures. With the exception of recording and analysis, the task can be learned through repeated practice. It would be best to increase the number of surface water staff; however, given the WRA's personnel shortage, it would be prudent to continue using staff from other fields.

If the personnel shortage persists, it may be worth considering securing the necessary budget and outsourcing the work to an external company.

3.1.5 Other Lessons Learned

(1) Participation of Non-surface Water Personnel in Capacity Building Activities

At the Tana Basin Office in Embu, when the JICA Expert Team held a lecture for capacity building on data organization, accumulation, and analysis, mainly for surface water personnel, there was active participation from staff in other fields. In the observation, organization, accumulation, and analysis of surface water, personnel from various areas, such as water quality, water rights, community affairs, information and communication, and interns, participated and eagerly absorbed the points to note regarding surface water. Although basic background knowledge is necessary, it was observed that having personnel from other fields actively participate in this way helped raise the level of the entire organization and deepen mutual understanding of each other's fields of expertise.

(2) Inclusion of Work Items Other than the Specifications for the Expert Work

During this expert work, the JICA Expert Team focused on completing the items listed in the specifications within the limited time. When the JICA Expert Team was on-site, the WRA requested for items that were not listed in the specifications or that went beyond the scope of the specifications. One notable example was the response to the damage caused by flooding across Kenya in April 2024. This flood highlighted the

importance of early flood warnings. It was recognized that the flood damage in Garissa, located in the middle and lower reaches of the Tana River basin, was particularly severe.

The JICA Expert Team proposed implementing a Flood Early Warning System (FEWS) with the Hydrological Monitoring and Drought and Flood Risk Assessment as the main focus. Specifically, a prototype system to predict floods in Garissa was developed using satellite rainfall data (GSMap) provided by Japan's JAXA and the River Runoff Inundation (RRI) model developed by Japan's Public Works Research Institute's International Center for Water Hazard and Risk Management (ICHARM).

(3) Expert Dispatch Period

The WRA commented that the dispatch period for experts was short, often resulting in lost opportunities for communication and feedback. This issue was particularly pronounced at the beginning of the work due to the impacts of the new coronavirus disease (COVID-19).

The expert in charge of "communications/innovation technology," who had the least input, only traveled for 15 days each time, which was insufficient for conducting thorough research or delivering lectures. For this reason, the parts that could not be handled on-site were compensated by holding online lectures and other remote methods. In addition, taking into consideration the time for on-site research and lectures, support was provided by hired personnel. Due to the cancellation of the local subcontracted work, the unused budget was reallocated to increase the frequency and the period of dispatch of the expert.

The JICA Expert Team believes that it is important to investigate and evaluate the current situation of the WRA more thoroughly, and collaboratively determine the direction during the dispatch period. The team emphasizes the importance of effective communication with counterparts to explore the ideal form to capacity-building activities.

4 Accomplishments of the Project Purpose

The project objective is to "strengthen WRA's capacity to manage hydrological information (observation, arrangement, storage, and analysis)." To achieve this, the following four outputs have been set:

Output 1: Hydrological Monitoring Network Update in Accordance with the Purpose of Monitoring at the Tana Basin Area

Output 2: Capacity Building on Hydrological Monitoring

Output 3: Capacity Building on Arrangement and Storage of Hydrological and Meteorological Data

Output 4: Capacity Building on Analysis and Utilization of Hydrological and Meteorological Data

As for Output 1: Hydrological Monitoring Network Update in Accordance with the Purpose of Monitoring at the Tana Basin Area

Regarding the update of the meteorological and hydrological monitoring plan in the basin, the JICA Expert Team investigated the actual monitoring situation from the beginning of the work in 2021 and found that observations are being carried out at 87 surface water observation stations, far exceeding the 26 proposed in the National Water Master Plan 2030. Among the 87 observation points, 11 were identified as non-functional due to destruction or theft, and 76 were found to be operational.

It was also found that some of these observation stations were installed by other development partners, such as the Nairobi Water Fund, making it difficult to reduce their number. Therefore, the outcome of this item has not been fully achieved.

For the time being, it is important to continue the river crossing survey and flow observation work while maintaining and managing the current 87 stations with WRA's budget. Observations that contribute to the issuance of water rights for the effective use of water resources should also continue.

Regarding the flood and drought situation, the actual conditions, frequency, and area of the damage were clarified through the collection of newspaper articles conducted from April 2022 to July 2024. Interviews at the Tana Basin Office and branch offices confirmed that the basin is taking measures to deal with floods and droughts. The next issue will be to explore how to utilize the data obtained through monitoring to improve flood and drought countermeasures.

As for Output 2: Capacity Building on Hydrological Monitoring

Throughout the first half of the on-site work, the operation status of the observation facilities and data transmission equipment was investigated, and an equipment operation plan was formulated from the perspective of the expert team. Based on the current status of the observation and data transmission equipment, training on the equipment was conducted, and the necessary resources were presented. In the future, it will be important for each river basin branch office to secure activity plans and the necessary resources.

Through a total of four on-site river crossing surveys and discharge measurements, the counterpart team, mainly made up of surface water officers, has steadily improved its observation capabilities. In order to solve challenges such as the aging of surface water personnel, it is necessary to further transfer technology and know-how from senior surface water personnel to younger personnel in the field. It is time to consider outsourcing surveying and observation work, taking into account the frequency of implementation and the number of personnel required.

As for Output 3: Capacity Building on Arrangement and Storage of Hydrological and Meteorological Data

As the work of arranging and storing data is mainly carried out or led by the WRA Headquarters, the JICA Expert Team interviewed the hydrologists and database staff at the WRA Headquarters to understand the procedures for organizing and storing data and to confirm the relevant guidelines. During these confirmation activities, the team found that WRA does not have quality control standards and that WRA staff perform quality control based on their experience and records. For this reason, the team has proposed clarifying the items and standards of the quality control standards.

In addition, when the JICA Expert Team interviewed staff about improving the operation and management of the database, the team found that the guidelines developed during the previous expert dispatch mission were not being used, and that "No: PM-3-3 Water Resources Monitoring Process" was being followed instead. The team also discovered that there was no system to record how the data manager responded to the process. Therefore, it is recommended that WRA record this.

As for Output 4: Capacity Building on Analysis and Utilization of Hydrological and Meteorological Data

Regarding the strengthening of analytical and utilization capabilities, multiple lectures were held at the Tana Basin Office in Embu, with participants including not only surface water personnel but also people from a wide range of fields of expertise. The lectures were held on various topics, such as an introduction to probability analysis and climate change analysis, and WRA's response during floods and droughts, with many participants in attendance. As part of this activity, a prototype of a flood early warning model using GSMaP (satellite rainfall) and RRI (inundation analysis) models was introduced. In addition, during the final fieldwork in September, seminars were held in Embu and Nairobi to introduce WRA's activities, with many stakeholders participating.

Project Monitoring Sheets

The first project monitoring sheet was prepared in July 2021 at the start of the project and has been updated accordingly since then, with the final version being in October 2024. Attachment 17 shows the version at the start of the project (July 2021) and at the end of the project (October 2024 version).

5 Recommendations

The following are the recommendations of the JICA Expert Team regarding matters that were noticed, areas requiring improvement, and future goals identified through working with local counterparts during the three-and-a-half-year activity period from April 2021 to October 2024.

5.1 Recommendation to the Government of Kenya

The recommendations, mainly from the perspectives of water management, flood and drought management, data organization, and quality control, are as follows:

(1) Periodic Flow Observation and Updating of H-Q Formula

River cross-section surveys and discharge measurements must be conducted periodically to grasp the amount of water resources at main observation points in the basin. Cross-section surveys must be conducted on the same line each time to track changes in the riverbed. A sample of a field notebook that can be used for both cross-section surveys and flow observations is shown in Attachment 15.

(2) Additional Employment of Surface Water Staff and Outsourcing of Flow Observation Work

During this capacity-building activity, the WRA staff were in charge of the river cross-section surveys and discharge measurement work, which were originally intended to be carried out by a subcontractor at the request of WRA. However, due to a shortage of personnel, the work relied on the support of two to four hired staff from the JICA Expert Team. In light of this, it is necessary to actively consider hiring additional staff dedicated to these tasks. Also, if the shortage of staff persists, outsourcing these tasks to an external company should be considered.

(3) Conduct Monitoring in Collaboration with Stakeholders in the Basin

This was particularly emphasized when the JICA Expert Team held an open seminar in September 2024, with the participation of relevant organizations. It is recommended that WRA conducts monitoring in collaboration with various stakeholders. In some cases, collaboration with relevant ministries and agencies in Kenya, as well as international development partners could provide support in addressing the financial difficulties that WRA faces.

(4) Periodic Training for Meteorological and Hydrological Data Monitoring, Training-of-Trainers Approach

The activities carried out during the project revealed that the WRA staff face challenges in handling tools such as ADV, levels, and current meters, as well as in processing the obtained data sets to produce various hydrological products. It is recommended to conduct periodic on-the-job training (OJT) covering discharge observation, data processing, and analysis. In this regard, applying a training-of-trainers (ToT) approach to effectively ensure sustainability should be considered. Given the situation where most of the current surface water personnel are expected to retire in a few years and it is challenging to secure replacements, hiring additional technical staff specializing in hydrology and other related fields is recommended. This measure would ensure the sustainability of the stations while supplementing the work of each staff.

(5) Efficient Quality Control of Observation Data, Including Through the Use of RPA

If quality control procedures and standards are clearly defined, they can be processed using Robotics Process Automation (RPA), enabling efficient data processing without human intervention. To achieve

this, quality procedures and standards must first be clearly defined. The JICA Expert Team proposed to define the items and standards for quality control during the activity period. The proposal is shown in Appendix 12.

(6) Cloud Management of Hydrological Data

The JICA Expert Team received feedback from staff at the BO and the SBO indicating that they cannot access the database at the headquarters. In addition, the ICT database staff stated that while data backups are regularly performed on hard disks in the same building, cloud storage or off-site backups are necessary to ensure the security of the data. To solve these issues, the JICA Expert Team recommends that hydrological data be managed on the cloud in the future.

(7) Checks to Complement Quality Control Procedures

The WRA has developed a Quality Management System (QMS) procedure for data entry and storage to ensure quality checks at each stage. However, the procedure does not indicate what changes or corrections were made to the data and how these were implemented. This could be due to the lack of clearly defined Quality Control (QC) criteria. It is necessary to record how QC and corrections were made in the “Remarks” column of the control standard number RG/3/3/1, enabling subsequent staff to understand the actions done in the past.

(8) Collaboration with the Kenya Meteorological Department (KMD) on Flood Damage Mitigation

Water level forecasts are essential for issuing warnings and advisories to reduce flood damage, with rainfall forecasts being vital for this purpose. KMD usually runs the Weather Research and Forecasting (WRF) model, a numerical forecasting system that predicts several meteorological variables, including precipitation, at least once a day. By collaborating with KMD, it is possible to contribute to flood damage mitigation in Kenya using rainfall forecast data from WRF. Although organizational barriers may exist due to different government ministries and agencies in charge, there is ample room to consider collaboration with KMD in the future.

(9) Collaboration with Kenya Electricity Generating Company (KenGen) on Flood Damage Mitigation

In Japan, it has been revealed that pre-release from multipurpose dams, such as hydroelectric and agricultural dams, contribute to mitigating flood damage downstream. Currently, KenGen is not conducting pre-releases of water, but in the future, it is expected to contribute to reducing flood damage downstream by conducting pre-releases based on KMD's predicted rainfall information. At that time, it is expected that WRA would cooperate by providing KenGen with river water level information downstream of the dam.

In addition, the following recommendations are made from the perspective of communication and innovation technology.

(10) Establishment of Operation and Maintenance (O&M) Departments at the Headquarters, Basin Offices and Basin Sub-offices

The WRA has installed 123 telemetering stations in six river basins across Kenya. It is highly recommended that an O&M department be established for the proper functioning of these telemetering facilities. This department would be responsible for ensuring that the equipment is in good condition, accurately tracking water resource volume, and maintaining a continuous observation system by

extending the life of the equipment through appropriate and sustainable O&M practices. Maintenance of spare parts and consumables for equipment that can be operated for about three years is essential for O&M work. A draft maintenance manual for flood forecasting and warning equipment is attached for easy reference (Attachment 16). If establishing an O&M department within WRA proves challenging, it is recommended that a dedicated O&M contract be concluded with an agency.

(11) Effective Use of Mike Workbench & Mike Zero Applications

The WRA has implemented the Mike Workbench and Mike Zero software applications and is conducting practical exercises in the Sagana – Gura Basin Management Unit. WRA staff who received training from the JICA Expert Team in July-August 2024 will be able to extend their experience to other sub-basins and are strongly encouraged to replicate and disseminate the training. The use of these applications should be strengthened to improve WRA's water management capacity.

In particular, the following items should be strengthened:

- Effective use of Mike Workbench and Mike Zero applications as integrated water resources management tools.
- Implementation of a comprehensive training program on these applications, as well as on the comprehensive management of telemetering stations, including real-time data analysis and emergency response protocols. The training should establish a connection between the observation data from the telemetering stations and the Mike Workbench database within the water resources information management platform operated at WRA headquarters.
- Establishment of a standardized protocol for data quality control to ensure consistent and accurate data utilization.
- Development and implementation of a regular upgrade and maintenance plan for telemetry stations to minimize downtime.
- Further development of pilot projects 4BE02 Tana, 4BC02 Tana Sagana, and 4BE10 Tana Rukanga as future project outcomes.

(12) Standardization

In order to achieve standard specifications and designs for efficient observation operations, it is recommended that the following be considered:

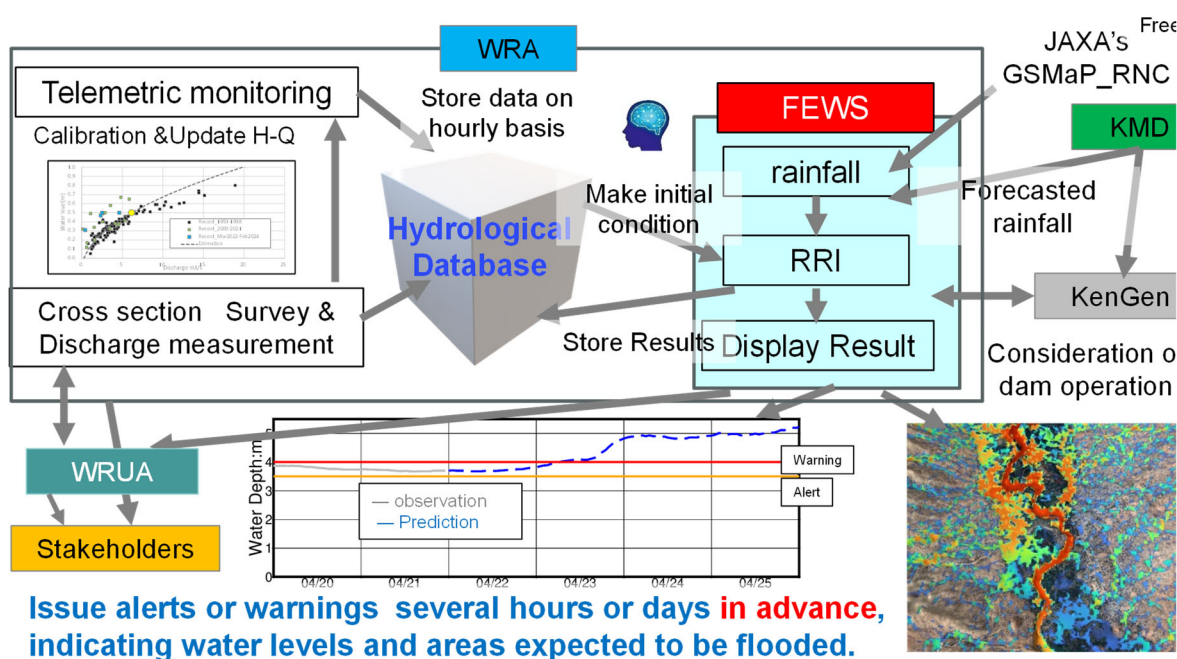
- Standardization of telemetry/data logger equipment specifications.
- Standardization of water level sensors (pressure type recommended) specifications.
- Standardization of civil engineering and observation building designs.

5.2 Recommendation to JICA

Recommendations from the perspective of water resources management and drought/flood management are as follows:

(1) Support for the Introduction of an Effective Early Warning System to Reduce Flood Damage

WRA has introduced an early warning system for floods in the Nzoia Basin of the Lake Victoria North basin area. However, as a lesson learned from the April 2024 flood, WRA has recognized the need for a system that can issue warnings before floods occur, not only for the Nzoia Basin but also for the other nine flood-vulnerable areas. Based on WRA's comments, the JICA Expert Team prepared a prototype for the Tana River basin. The team recognized that to establish an effective early warning system, WRA must build a practical hydrological monitoring database and collaborate with the KMD.



(Source: JICA Expert Team)

Figure 5-1 Proposed Flood Early Warning System (FEWS)

In this project, the study was conducted only for the Tana River basin. However, since GSMaP, which was used as the rainfall data, covers almost the entire globe, this technology can be deployed not only in the Tana Basin but also throughout Kenya and other African countries, provided hydrological observations are conducted in the respective basin. These are Japanese-made technologies, and it is expected that they will be actively utilized in JICA's technical cooperation on disaster prevention and mitigation.

In addition, the following recommendations pertain to communication and innovation technology.

The latest technologies in communication and topographical surveying, such as drones and AI, are widely applied in the fields of weather and flood monitoring systems, not only in Japan but also internationally. The application of these technologies to the fields of water resource management and

disaster prevention management is progressing, and it is recognized that the active introduction of these technologies will be promoted through Japan's ODA scheme.

Through this work, the adoption of the following technologies is recommended for WRA activities:

- X-band radar facility: Listed by the Ministry of Internal Affairs and Communications as a Japanese technology for deployment in overseas markets in 2025.
- Flood detection system using Bluetooth devices.
- Disaster information platform.

(2) X-Band Radar

S-band and C-band radars, used for weather measurement, are capable of wide range and high altitudes, making them suitable for weather forecast such as typhoons, hurricanes, and cyclones. Meanwhile, the X-band radar can measure regional weather conditions, such as heavens open and guerrilla rainstorm, and heavy rain in small area in the city.

Since flood due to abnormal weather has occurred as a worldwide phenomenon recently, early detection and forecasting of floods are required. The X-band radar is effective for flood forecasting and warning system (FFWS) activity as mentioned below:

The X-band radar detects rain clouds and measures rainfall with a high resolution 150 m x150 m mesh in real time.

The X-band radar can issue flood warning for 1-2 minutes.

The features of C-band and X-band radars are summarized in the table below.

Features and comparison of C-band and X-band radars are shown in Table 5-1.

Table 5-1 Features and Comparison of C-Band and X-Band Radars

Radar Type	C-band Radar	X-band Radar
Frequency/Wavelength	4-8 GHz/Approx. 5 cm	8-12 GHz/Approx. 3 cm
Purpose of measurement	Live rain monitoring (large area range: 400 km radius)	- Live rain monitoring (* small area range: 80-120 km radius) - Rain cloud observation
Typical installation place	Special designed building to withstand weight of the radar	Steel tower such 20-30 m height
Measurement interval	5 min.	1 min.
Time lag	5-10 min.	1-2 min.
Resolution	1 km	150/250 m
* For compact equipment designated by a vendor in Japan, it can cover a radius of 40 km and can be installed on the roof of a five- story building instead of requiring a steel tower		

(Source: JICA Expert Team)

(3) Flood Detection System with Bluetooth Devices

Research and development are being carried out in Japan for a more cheaper flood detection system that uses Bluetooth devices instead of conventional pressure-type water level gauge. Some of these devices have already been put to practical use. As the system is cheap and easy to install, the system is expected

to be introduced to overseas markets.

(4) Disaster Information Platform

This system consolidates various types of information and data, such as the following, onto a single platform to help local governments collect flood information and issue evacuation instructions to residents. It is being developed by many companies in Japan. The system is considered effective for disaster prevention management, and there are aspirations to expand it to overseas markets.

- Water level sensor observation data (including future data from drones)
- Satellite data
- People flow data during disasters
- Traffic data during disasters
- Flood prediction data
- AI-generated prediction information
- AR/AVR technology information

Photos

Photographs

1. Project Briefing and Site Reconnaissance at the start of the Project



The first meeting with Tana Basin Office in Embu for project briefing (2021/7/7)



One of the Computer Terminals for Hydrological Database Access (2021/7/7)



Candidate Gauging Station for Discharge Measurement Practices, 4AC04 New Chania in Muranga SBO (2021/7/7)



Status of Staff Gauges at 4AC04 New Chania (2021/7/7)



Project Briefing at Meru SBO (2021/7/8)



Computer Terminal for accessing Hydrological Database at Meru SBO (2021/7/8)



Candidate Gauging Station for Discharge Measurement Practices, 4F10 Kathita in Meru SBO. This Station was rehabilitated in the Previous Advisory Service. (2021/7/8)



Candidate Gauging Station for Discharge Measurement Practices, 4F10 Kathita in Meru SBO. Staff Gauges in the Left Bank (2021/7/8)



Candidate Gauging Station for Discharge Measurement Practices, 4F10 Kathita in Meru SBO. The first staff gauge is slightly leaning. (2021/7/8)



Candidate Gauging Station for Discharge Measurement Practices, 4F10 Kathita in Meru SBO. Gabion mattress installed in the Previous Advisory Activities. (2021/7/8)



Candidate Gauging Station for Discharge Measurement Practices, 4F10 Kathita in Meru SBO. A small building for accommodating data logger system. (2021/7/8)



Candidate Gauging Station for Discharge Measurement Practices, 4F10 Kathita in Meru SBO. Data retrieval work The logger is being operated in good condition. (2021/7/8)



Project Briefing at MurangaSBO (2021/7/9)



Project Briefing at MurangaSBO (2021/7/9)



Candidate Gauging Station for Discharge Measurement Practices, 4BF01 Saba Saba in Muranga SBO. (2021/7/9)



Candidate Gauging Station for Discharge Measurement Practices, 4BF01 Saba Saba in Muranga SBO. (2021/7/9)



Site visit to Telemetering Station at 4DA11 Thiba. Outer view of the station building. (2021/10/26)



Site visit to Telemetering Station at 4DA11 Thiba. Telemetering Panel (up) and a car battery for power supply. (2021/10/26)



Site visit to Telemetering Station at 4DA11 Thiba. Outer view of the station building. Pressure sensor and cable. (2021/10/26)



Site visit to Telemetering Station at 4DA11 Thiba. Staff Gauge for manual reading. (2021/10/26)



Telemetry Station in Tana Basin, 4BE10 Tana Rukanga. The door is broken with its concrete base and all the equipments are taken away. (2021/10/26)



Telemetry Station in Tana Basin, 4BE10 Tana Rukanga. 4BE10 Tana Rukanga. Staff Gages located in the left bank (2021/10/26)

2. Interview Survey for the Status of Gauging Stations and Related Facilities



Interview Survey on the Status of Gauging Stations at Meru SBO. Surface Water Officer (SWO) Mr. Alex Kimotho. (2022/6/22)



Interview Survey on the Status of Gauging Stations at Embu BO. From the left, Ms. Jane Njoroge Wairimu of Muranga SBO, Ms. Jane Njuguna of Kerugoya SBO, Okamura (JICA Experts Team) and Technical Manager Mr. Munyao, Tana BO. (2022/6/2)



Status of Observation Equipment in Muranga SBO. Current Meter (up) and Surge Equipment (low). They are well maintained. (2022/6/10)



Status of Observation Equipment in Muranga SBO. A Form Work for Gauging Post (left) and Gauge Plates (right). (2022/6/10)



Interview Survey on the Status of Gauging Stations at Kerugoya SBO (2022/6/9)



A Report Meeting at JICA Kenya Office before returning to Japan. (2022/6/17)



A Courtesy Call and Project Briefing to a New Basin Coordinator, and a New Technical Manager of of Tana BO. (2023/1/25)



Site Reconnaissance to Regular Gauging Station 4DD02 Thiba. The 1st and the 2nd Staff Gauges. (2023/1/25)



Site Reconnaissance to Mwea Irrigation Project, Thiba Dam(2023/1/26)



Irrigation Outlet of Thiba Dam. Flow Release of 5 m³/s implemented. (2023/1/26)



A Check Dam located at the upstream part of Thiba Dam (2023/1/26)



Thiba Dam Body looking from the left bank side. (2023/1/26)

	
An Intake Facility for Water Supply to Nairobi, Maragua Intake (2023/1/27)	A Group Photo of Participants at Maragua Intake (2023/1/27)
	
Site Reconnaissance to Flood Forecast & Warning System Candidate, 4F13 Tana Grandfalls (2023/5/22)	Site Reconnaissance to Flood Forecast & Warning System Candidate, 4F13 Tana Grandfalls. Outcrops are observed on the left bank. (2023/5/22)
	
Site Reconnaissance to 4F13 Tana Grandfalls. Observation is made by using Nine Staff Gauges. (2023/5/22)	At 4F13 Tana Grandfalls. River Water Depth Measurement using boat. Average depth was around Four meter. (2023/5/22)
3. Capacity Building Workshop related to Data Analysis	
	
A Capacity Building Workshop related to Data Analysis at Tana Basin Office in Embu. (2023/10/12)	A Capacity Building Workshop related to Data Analysis. (2023/10/12)



A Capacity Building Workshop related to Analysis Method of Climate Change (2023/10/13)



Exercise during Capacity Building Workshop (2023/10/13)

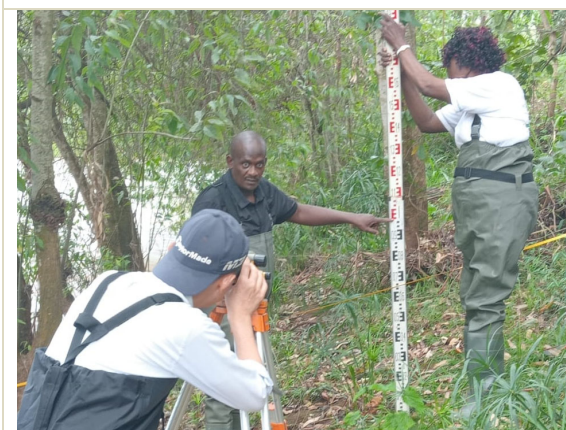


A Capacity Building Workshop related to Data Analysis. Many Participants other than Surface Water Officers attended. (2023/10/13)



A Group Photograph of Capacity Building Workshop (2023/10/13)

4. Exercises related to River Cross-Section Survey and Discharge Measurement



Exercises of River Cross-Section Survey and Discharge Measurement at 4AC03 Sagana (2024/2/7)



Exercises of Discharge Measurement at 4AC03 Sagana (2024/2/7)



Exercises of Discharge Measurement at 4AC03 Sagana (2024/2/7)



Exercises of Discharge Measurement at 4AC03 Sagana. The Water Level at 0.59 m. (2024/2/7)

	
Exercise of River Cross-Section Survey at 4DC03 Rupingazi (2024/2/8)	Exercise of River Cross-Section Survey at 4DC03 Rupingazi (2024/2/8)
	
Exercises of River Cross-Section Survey and Discharge Measurement at 4F10 Kathita. Preliminary Check of River Water Depth prior to measurement (2024/2/9)	Preparation of a Boat for Observation Works at 4F10 Kathita. (2024/2/9)
	
River Cross-Section Survey at 4F10 Kathita. (2024/2/9)	River Cross-Section Survey at 4F10 Kathita. (2024/2/9)
5. A Review Session for River Cross-Section Survey and Discharge Measurement, together with other Workshops related to Analysis Works, and Public Seminars.	
	
A Review Session of River Cross-Section Survey and Discharge Measurement at Tana Basin Office in Embu. (2024/2/14)	Exercise to Estimate Discharge from the Observed Results. (2024/2/14)



A Review Session of River Cross-Section Survey and Discharge Measurement. A session related to Required Equipment for Observation. (2024/2/14)



A Review Session of River Cross-Section Survey and Discharge Measurement. Closing Remarks from the Participant. (2024/2/14)



A Workshop Related to Analytical Works at Tana Basin Office in Embu (2024/6/10)



A Workshop Related to Analytical Work. A Group Photo of Participants. (2024/6/10)



A Publication Seminar of the Activities of WRA in Embu. (2024/9/17)



A Group Photo of Participants to Public Seminar in Embu. (2024/9/17)



Opening Remarks by Mr. Hamano, Senior Representative of JICA Kenya Office at Publication Seminar on WRA's Activities in Nairobi. (2024/9/19)



Participants to Publication Seminar on WRA's Activities in Nairobi (2024/9/19)



Participants to Publication Seminar on WRA's Activities in Nairobi (2024/9/19)



A Group Photo of Participants to Public Seminar in Nairobi on WRA's Activities (2024/9/19)

Appendix 1 Newsletter

List of Newsletters

No.1 Issued in July 2021 No.2

(missing number)

No.3 Issued in April 2022

No.4 Issued in June 2022

No.5 Issued in December 2022

No.6 Issued in January 2023

No.7 Issued in May 2023

No.8 Issued in November 2023

No.9 Issued in February 2024

No.10 Issued in June 2024

No.11 Issued in July 2024

No.12 Issued in September 2024



Kenya Water Resources Advisor

JICA Experts Team

No.1 (July 2021)

Newsletter No.1

The later of June 2021, two Japanese Experts commenced on the Activity “Kenya Water Resources Advisor”. During their stay in Kenya, they have carried out the kickoff meeting and site reconnaissance in Tana Catchment Area, and prepared Work Plan for the Activity. This newsletter describes the project outlines and work activities done recently.

1. Project Background

A study of "National Water Master Plan 2030 (NWMP 2030) was conducted by Water Resources Management Authority (WRMA: former governmental agency now renamed WRA) as the executing agency with assistance of Japan International Cooperation Agency (JICA) during the period from October 2010 to November 2013. The study supported formulation of water resources development and management plans for all the six catchment areas in the country as well as the formulation of action plans for strengthening water resource management capacity.

In 2017, aiming at strengthening of water resource management based on appropriate monitoring, JICA implemented activities of "JICA Expert for Water Resources Management" from January 2017 to September 2019. In the activity, various activities were implemented such as discharge measurement and installation of water level gauges, which contributed much to the capacity building of WRA staff in its headquarters, Tana Regional Office as well as other five regional offices. However, it is further required to level up the capacity of WRA staff, so that WRA staff is able to achieve early implementation of plans formulated by NWMP 2030 and to perform the tasks stipulated in the new Water Act 2016.

In this connection, a new activity was launched, which we can call as “JICA Expert for Water Resources Advisor.”

Two Experts dispatched in the first assignment



OKAMURA Takeshi
Team Leader, Water Resources
Management Expert



KATO Yusuke
Hydrological Monitoring/
Flood and Drought Risk

2. Objectives

Based on the project background as mentioned, objectives of the Activity are as follows:

- 1) **Strengthening of observation network.**
- 2) **Improvement and fixation of capacities related to data observation, arrangement, storage, and analysis.**
- 3) **Utilization of observed results which are required for solutions of water resources related issues such as Flood, Drought, and Climate Change.**

3. Outputs

The Activity is "Individual Expert" scheme and the objective is to enhance capacity of water resources management in WRA with the following four expected outputs through JICA Experts Team.

- Output 1: Hydrological Monitoring Network Update in accordance with the Purpose of Observation
- Output 2: Capacity Building on Hydrological Monitoring
- Output 3: Capacity Building on Arrangement and Storage of Hydrological and Meteorological Data
- Output 4: Capacity Building on Analysis and Utilization of Hydrological and Meteorological Data

4. Project Duration

The Project is carried out for the period of about 36 months from April 2021 to April 2024.

5. Target Area

The activities will be mainly performed in the WRA headquarters. Practical site activities will be held in the Tana Catchment Area out of six catchment areas of WRA.

6. Working Activities

To achieve four outputs, total 15 activities will be conducted with the assistance of JICA Experts Team.

Output 1 Hydrological Monitoring Network Update in accordance with the Purpose of Observation

- Activity 1.1 Survey on recent flood and drought damages as well as countermeasures for such damages
- Activity 1.2 Survey on support activities by other development partners in the field of water resources
- Activity 1.3 Clarification on the positions/purposes of each monitoring station from the viewpoint of flood and drought risk evaluation
- Activity 1.4 Review of monitoring plan of Tana Catchment Area from the viewpoint of effective utilization of the monitoring results

Output 2 Capacity Building on Hydrological Monitoring

- Activity 2.1 Confirmation on operational status and analysis of issues on monitoring facilities and data transmission facilities
- Activity 2.2 Support on preparation of plan of operation for data transmission facilities
- Activity 2.3 Training of observation facilities and data transmission facilities
- Activity 2.4 Reinforcement of capacity on monitoring at site including preparation of H-Q curve

Output 3 Capacity Building on Arrangement and Storage of Hydrological and Meteorological Data

- Activity 3.1 Quality improvement guidance and preparation of quality control standards
- Activity 3.2 Confirmation on the current status and improvement on operation and management of database

Output 4 Capacity Building on Analysis and Utilization of Hydrological and Meteorological Data

- Activity 4.1 Guidance on basic analysis: implementation on flow regime arrangement/compilation and probabilistic analysis
- Activity 4.2 Analysis on climate change affect
- Activity 4.3 Discussion and compilation on the function of WRA as well as utilization and analysis of monitoring results droughts as well as utilization and analysis of monitoring results
- Activity 4.4 Discussion and compilation on the measures during droughts as well as utilization and analysis of monitoring results
- Activity 4.5 Discussion and notification to related organizations on the hydrological and meteorological data

7. Site Reconnaissance in TCA from 7th to 9th July 2021

JICA Experts Team carried out the site reconnaissance in TCA jointly with WRA staff to confirm the current condition of river gauging stations and selected the candidate RGSs for Activity 2.4.

From WRA, the following staff joined the meeting/site reconnaissance:

Ms. Pauline Nyamu (HQ-SWO), Mr. John Munyao (RO-RM), Mr. Philip Munyua (RO-RTM), Mr. Samuel Ndung'u (RO-SWO), Mr. Alex Kimotho (SRO Meru, SWO), Ms. Patricia Musau (SRO-Murang'a SRM), Ms. Jane Wairimu (SWO-Murang'a SRM) and Mr. John Gitau (Senior Programme Officer, JICA).



8. Way Forward

Three JICA experts with national staffs are now ready to implement 15 activities to achieve the four outputs together with counterparts from WRA. The project will run for three years, and during which the stay of the JICA experts will be intermittent. Corporation with WRA staffs is a key factor in achieving the project goals.

Contact: JICA Experts Team

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AZUMA	To be informed	azuma-ys@n-koei.jp



Kenya Water Resources Advisor

JICA Experts Team

No.3 (April 2022)

Newsletter No.3

From March to April 2022, the third fieldwork was conducted by two Japanese experts and two national experts. This newsletter describes the project works during the third activity, especially discharge measurement

1. Project Background

A study of "National Water Master Plan 2030 (NWMP 2030)" was conducted by Water Resources Management Authority (WRMA: former governmental agency now renamed WRA) as the executing agency with the assistance of the Japan International Cooperation Agency (JICA) during the period from October 2010 to November 2013. The study supported the formulation of water resources development and management plans for all the six catchment areas in the country as well as the formulation of action plans for strengthening water resource management capacity.

In 2017, aiming at strengthening water resource management based on appropriate monitoring, JICA implemented activities of "JICA Expert for Water Resources Management" from January 2017 to September 2019. In the activity, various activities were implemented such as discharge measurement and installation of water level gauges, which contributed much to the capacity building of WRA staff in its headquarters, Tana Regional Office as well as other five regional offices. However, it is further required to level up the capacity of WRA staff, so that they can achieve early implementation of plans formulated by NWMP 2030 and perform tasks stipulated in the new Water Act 2016. In this connection, a new activity was launched, which it called "JICA Expert for Water Resources Advisor."

2. Nomination Count Part (Nov. 2021)

Jared Otieno	Head Office	Team Leader
Ken Ochieng	Head Office	
Samuel Ndungu	Embu RO	(Augusta)
Jane Wanja Njuguna	Kerugoya SRO	
Alex Mugo Kimotho	Meru SRO	
Faith Wanja Mbathi	Murang SRO	
(Jane Wairimu)	Murang SRO	

3. Activity

Cross-section survey

Except for the concrete surfaced sections, the profile of river cross-sections is not stable and needs to be updated, especially after the floods. JICA Experts Team expects WRA staff to understand how much the profile changes and recognize the importance of conducting a regular survey through this cross-section survey activity. In this connection, the cross-section survey will be carried out four times at the exact location for two years. (refer to Activity 2-4 of Work Plan, on page 14).

Discharge measurement

After WRA is aware of the changing cross-sections, the H-Q curve must be updated to apply to the new cross-section survey date. Through this discharge measurement, JICA Experts Team expects that WRA staff will understand the impact of the difference between the old data and the new data on the result.

3. Target Station(s)

Gauging Station	Location	SRO
4DC03	Rupingazi	Kerugoya
4CA03	Sagana	Muranga
4F10	Kathita	Meru

4. Timing and schedule

2 times x 2 years = 4 times, before the rainy season and after the rainy season

2022											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		●						●			
2023											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		●			●						

5. Exercise Schedule

1st-day afternoon Preparation/Understanding of the importance of discharge measurement/cross-section survey
 2nd-day whole day Discharge measurement/cross-section survey
 3rd-day morning Check the data and feedback

6. Result of Exercise

Observed discharge volume (1st/2nd time)

RGS	1st	2nd	Difference
4DC03	0.47 m ³ /s	0.38 m ³ /s	23.7%
4CA03	1.89 m ³ /s	1.57 m ³ /s	20.4%
4F10	5.80 m ³ /s	5.89 m ³ /s	less than 2%

The target deviation is less than 10%.

The measured flow direction seems not to be correct.

7. Key Findings of the Exercise

- ✓ Knowledge seems enough for SWO(s)
- ✓ Spacing for measuring is not clear (Note 1)
- ✓ Measurement points for flow velocity are not sufficient (Note 2)
- ✓ Need the assistant to understand the mechanism and tools (Note 3)
- ✓ The equipment including survey and wandering boots, is not properly and well maintained.

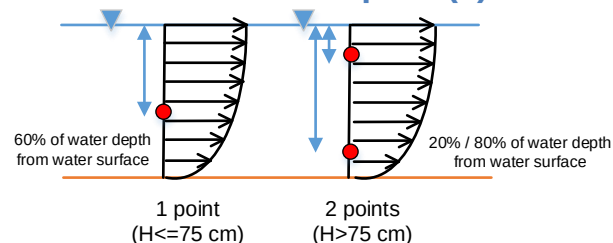
8. Way Forward

In 2022, the election will be held in August. The next exercise will be carried out in September/October 2022 (before the rainy season).

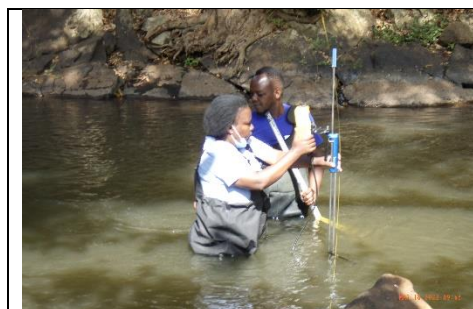
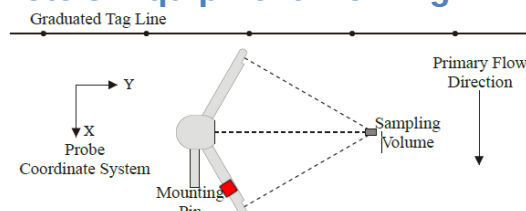
Note 1. Standard Spacing

Water Surface Width (m)	Spacing between flow velocity (m)
Less than 10	10 - 15% of water surface width
10 - 20	1.0 m - 2.0 m
20 - 30	2.0 m - 3.0 m

Note 2. Measurement point(s)



Note 3. Equipment Working Principles



Working with C/P (Ms. Jane and Mr. Job) at RGS 4DC03 (Rupingazi), Kerugoya



Working with C/P (Ms. Faith and Ms. Jane) at RGS 4CA03(Sagana), Muranga



Working with C/P (Mr Kimotho, Mr Bonface, Mr Gordon, and Ms Teresa) at RGS4F10 (Kathita) in Meru



Kenya Water Resources Advisor

JICA Experts Team

No.4 (June 2022)

Newsletter No.4

The fourth fieldwork was carried out by a team of three Japanese Experts and three National staff in June 2022. This newsletter describes the project works during the fourth activity and the objectives sought to be met.

1. Project Background

A study of "National Water Master Plan 2030 (NWMP 2030)" was conducted by Water Resources Management Authority (WRMA: former governmental agency now renamed WRA) as the executing agency with the assistance of the Japan International Cooperation Agency (JICA) during the period from October 2010 to November 2013. The study supported the formulation of water resources development and management plans for all six catchment areas in the country, as well as action plans for strengthening water resource management capacity.

In 2017, aiming to strengthen water resource management based on appropriate monitoring, JICA implemented "JICA Expert for Water Resources Management" activities from January 2017 to September 2019. In action, various activities were implemented, such as discharge measurement and installation of water level gauges, which contributed much to the capacity building of WRA staff in its headquarters, Tana Regional Office, and five other regional offices. However, it is further required to level up the capacity of WRA staff so that WRA staff can achieve early implementation of plans formulated by NWMP 2030 and perform the tasks stipulated in the new Water Act 2016. In this connection, a recent activity called "JICA Expert for Water Resources Advisor" was launched.

2. Main Objective

Site Reconnaissance was conducted in the WRA Tana Basin, mainly; in Embu, Meru, Kerugoya, and Murang'a, and the main objective were:

- Reinforcement on Capacity of WRA on Hydrological Information Management in terms of Observation, arrangement, storage, and analysis.

3. Activities

Activity 1-2: Survey on support activities by other development partners.

Activity 1-3: Clarification of the positions/purposes of each observation station from the viewpoint of flood and drought risk evaluation.

Activity 1-4: Review of monitoring plan of Tana Catchment Area from the viewpoint of effective utilization of the observation results.

4. Site Visits

Site visits were conducted in Meru on 2nd and 3rd June and later in Kerugoya and Murang'a sub-regions on 9th and 10th June, respectively, and the team observed that;

- WRA maintains 87 stations (manual, automated, and telemetric) at the Sub-regional office. Manual stations are observed and recorded by gauge readers, while automatic stations are logged regularly and time series data uploaded into MIKE Info at the sub-regional level.
- A range of 26-30 stations is recommended by NWMP 2030 and Kenya Water Security and Climate Resilience Project (KWSCR) 2020 for flood and drought monitoring purposes.
- Station 4F10 in Meru, Kathita, with a data logger installed by JICA, is in good condition.
- KWSCR and Nairobi Water Fund installed additional Meteorological stations with data loggers and telemeters in early 2022.
- Hobo-type water level sensors were mainly installed under Kenya Climate Smart Agriculture Project (KCSAP) and Nairobi Water fund in Murang'a and Kerugoya sub-regions.
- Several defects were observed in stations due to vandalism and flood damages.

5. Results

Status of Regular Gauging Stations in the Tana Basin Area

	T	O	NO	TS	DL	V	NR
Kerugoya	13	13	0	7(54%)	0	1	2(15%)
Murang'a	53	47	6	11(21%)	19(36%)	7	14(26%)
Meru	16	13	3	3(19%)	4(25%)	0	0
Sub-total	82	73	9	21(26%)	23(28%)	8	16(20%)
Garissa	5	3	2	1(20%)	0	0	0
TOTAL	87	76	11	22(25%)	23(26%)	8	16(18%)

T-Total,

O-Operational,

NO-Not Operational,

TS-Telemetric Stations,

DL-Data Logger,

V-Vandalized,

NR- Need Rehabilitation

6. Findings

- The status for surface water stations is updated for sub-basins.
- Operational challenges identified.
- Stations for capacity building identified.
- Check for Procedures for data observation, arrangement, storage, and analysis.
- Additional information of Flood prone areas was identified.



1. Meeting at Embu Regional office, Kerugoya, and Murang'a Sub-Regional Offices Respectively



2. SEBA Data Logger in station 4DA11(Thiba). 2&3Newly Installed Telemetric Meteorological station and staff gauge outside Murang'a Sub-Regional Office



3. The housing structure of HOB0 data logger in 4BE01(Maragua) 2. Checking of the equipment 3. Faith demonstrates data reading from the logger to the PC through the coupler.





Kenya Water Resources Advisor

JICA Experts Team

No.5 (December 2022)

Newsletter No.5

From November to December 2022, the fifth field work was conducted, with two Japanese Experts and three national staffs. This newsletter describes the project activities carried out during this period and the outcome achieved.

1. Project Background

A study of "National Water Master Plan 2030 (NWMP 2030)" was conducted by Water Resources Management Authority (WRMA: former governmental agency now renamed WRA) as the executing agency with assistance of Japan International Cooperation Agency (JICA) during the period from October 2010 to November 2013. The study supported formulation of water resources development and management plans for all the six catchment areas in the country as well as the formulation of action plans for strengthening water resource management capacity.

In 2017, aiming at strengthening of water resource management based on appropriate monitoring, JICA implemented activities of "JICA Expert for Water Resources Management" from January 2017 to September 2019. In the activity, various activities were implemented such as discharge measurement and installation of water level gauges, which contributed much to the capacity building of WRA staff in its headquarters, Tana Regional Office as well as other five regional offices. However, it is further required to level up the capacity of WRA staff, so that WRA staff is able to achieve early implementation of plans formulated by NWMP 2030 and to perform the tasks stipulated in the new Water Act 2016.

2. Activities

This newsletter highlights the hydrological activities undertaken in December 2022 which focuses on discharge measurement and river cross-section survey at three stations; Kathita 4F10, Sagana 4AC03, and Rupingazi 4DC03. The activities **were** undertaken to enhance the understanding of changes in the river cross-sectional profile before and after the high flow.

3. Site Visits

Visit to Embu RO

On 1st December 2022, one Japanese Expert and two national staff visited the regional office (RO) with a view to appraising the Office on the status of the project and plan for the current activities. The highlights of the issues discussed include:

- Hydrological monitoring to continue with the activities focusing on the river cross-sectional survey and discharge measurement. The basin was receiving rain at the time resulting in moderately high water levels in the rivers posing a challenge to the intended activities.

- JICA Expert Team will prepare an operational and maintenance guide/manual on hydrological monitoring based on the available equipment in the respective offices for ease of reference in the future.

- JICA Kenya office is concerned with the progress of project implementation and hence a proposal to organize a project implementation meeting between JICA and WRA to share an update on the project's progress was suggested. The first meeting was proposed to be held in February 2023.

Visit to Thiba, Murang'a and Meru SROs

On 1st, 2nd, and 6th December 2022, JICA Experts Team paid a courtesy visit to Thiba, Upper Tana, and Kathita-Mutonga Sub-Basin Offices (SROs), respectively. The objective was;

- Share the project's progress report
- Agree on planned activities
- Confirm availability of counterpart staff for the scheduled activities.
- Carry out a reconnaissance visit to River Rupingazi (4DC03), Sagana (4CA03) and Kathita (4F10) to assess the river water level for planning purposes.

Discharge Measurements

On 9th December JICA Experts Team together with WRA officers from Embu, Murang'a, and Kerugoya visited Rupingazi 4DC03 and jointly carried out the discharge measurement and cross-section survey. The session was also used to train the surface water officers on the use of a propeller-type current meter supplied by JICA.

This was to take advantage of the idle equipment as an alternative to the ADV. Mr. Kato and Mr. Masika illustrated the use of the dumpy level and the current meter by wading respectively. The exercise was successfully done achieving both discharge measurement and the cross-sectional profile at the station.



Photo 1: Mr. Kato explaining the principle of leveling at the Rupingazi station 4DC03 during the river cross-sectional survey



Photo 2: Mr. Masika illustrating the use of a propeller-type current meter during discharge measurement at 4DC03

On 14th December 2022, JICA Experts Team visited the Kathita-Mutonga sub-basin to undertake discharge measurement and the river cross-section survey at Kathita 4F10.

A local volunteer was engaged to assist in wading across the river during the survey. However, discharge measurement was not possible due to the high water level (the deepest part was 1.45 m).



Photo 3: Mr. Kato and Mr. Kimotho taking bookings at 4F10



Photo 4: Mr. Masika and a local volunteer wading through the river during the cross-section survey at Kathita 4F10

On 19th December 2022, the JICA Experts Team visited the Upper Tana sub-basin for the same exercise at Sagana (4AC03). The activity was carried out jointly by JICA Experts Team and the Surface Water Officer from the Murang'a office Ms. Jane Wairimu. Mr. Kato and Mr. Masika took the lead in undertaking the cross-sectional survey and discharge measurement respectively.



Photo 5: Ms. Jane and Ms. Iluba taking the readings during the activity



Photo 6:
Discharge
measurement in
progress using
the propeller-
type current
meter at Sagana
4AC03

4. Result of the Exercise

Observed discharge volume (1st/2nd time)

RGS	1st	2nd	Difference
4DC03	1.23m ³ /s	1.13m ³ /s	8.1%
4CA03	6.80m ³ /s	5.60m ³ /s	17.5%
4F10	No discharge measurement		

5. Key Finding from the Exercise

- To generate a reliable rating curve, it is necessary to observe discharge measurements more than two times at the same location.
- It is essential to observe discharge measurement consistency to less than 10% variation between successive runs.
- There is room to improve WRA staff's **preparation** and **technical skills**.

6. Way Forward

The next exercise is scheduled for March 2023 before the onset of the rainy season.

[Lessons]

Recently, WRA officers in Tana have been using current meters such as ADVs. These devices have automatic calculation functions. So WRA officers can record flow velocities and depths at the same location and receive discharge volumes from the display.

Discharge volume calculations are based on the following methodology;

$$Q = Q_1 + Q_2 + Q_3 + \dots Q_n$$

$$Q_1 = h_1 \times v_1 \times w, Q_2 = h_2 \times v_2 \times w,$$

$$Q_3 = h_3 \times v_3 \times w \dots$$

$$Q_n = h_n \times v_n \times w$$

Where h: water depth (measured), v: flow velocity (measured), and

w: intervals for measurement (even, i.e. 1.0 m)

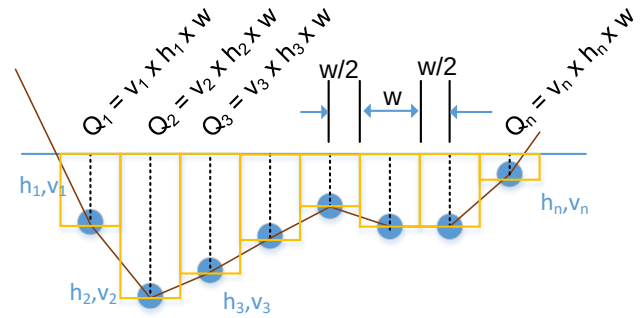


Figure -1 Discharge Volume Calculation (Présent)

During the December activities, JICA Experts Team proposes the idea of measuring the different points for water depth and velocity.

As shown in Figure -2, the orange points are to measure the flow velocity, and the blue points are to measure the water depth. The flow area is thus a trapezoid, as shown in Figure 3, which needs to be calculated manually but gives a more accurate volume, especially in low flow.

$$Q = Q_1 + Q_2 + Q_3 + \dots Q_n$$

$$Q_1 = (h_1 + h_2) \times v_1 \times w,$$

$$Q_2 = (h_2 + h_3) \times v_2 \times w,$$

$$Q_3 = (h_3 + h_4) \times v_3 \times w \dots$$

$$Q_n = h_n \times v_n \times w$$

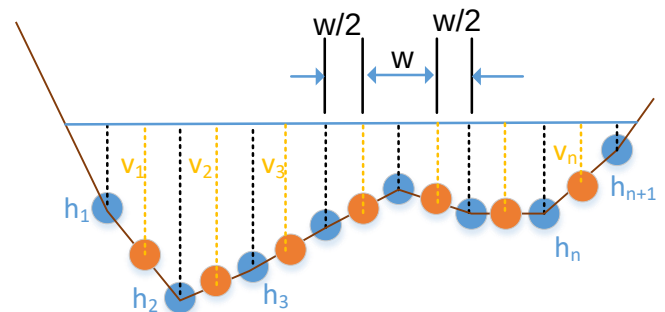


Figure -2 Measuring points (flow velocity and water depth)

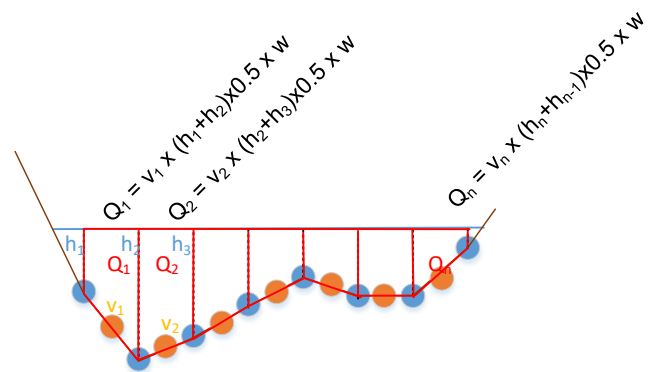


Figure -3 Discharge Volume Calculation (Propose)



Kenya Water Resources Advisor

JICA Experts Team

No.6 (January 2023)

Newsletter No.6

Telecommunication Expert Mr Yasushi Azuma conducted Capacity Building activity on observation and data transmission facilities; the training was disseminated via an online platform (Teams) on the 12th of January, 2023. The goal is to strengthen WRA's Capacity in Hydrological Monitoring and Data management with practical installation examples in Japan and the Philippines.

1. Project Background

A study of "National Water Master Plan 2030 (NWMP 2030)" was conducted by Water Resources Management Authority (WRMA: former governmental agency now renamed WRA) as the executing agency with the assistance of the Japan International Cooperation Agency (JICA) during the period from October 2010 to November 2013. The study supported the formulation of water resources development and management plans for all six catchment areas in the country, as well as action plans for strengthening water resource management capacity.

In 2017, aiming to strengthen water resource management based on appropriate monitoring, JICA implemented "JICA Expert for Water Resources Management" activities from January 2017 to September 2019. In action, various activities were implemented, such as discharge measurement and installation of water level gauges, which contributed much to the capacity building of WRA staff in its headquarters, Tana Regional Office, and five other regional offices. However, it is further required to level up the capacity of WRA staff so that WRA staff can achieve early implementation of plans formulated by NWMP 2030 and perform the tasks stipulated in the new Water Act 2016. In this connection, a recent activity called "JICA Expert for Water Resources Advisor" was launched.

2. Main Objective

Capacity Building to improve WRA staff awareness, adequacy, effectiveness, and decision-making on observation facilities for water resource and flood risk management with the aim of:

- Reinforcement of the Capacity of WRA on Hydrological Information Management in terms of Observation, arrangement, storage, and analysis through training on observation and data transmission facilities.

3. Activities

Activity 2-3: Training on Observation facilities and data transmission facilities

4. Capacity Building Activities

Some of the topics of discussion were as follows;

- Selection of Water Level Gauge type and Introduction to FFWS (Flood Forecast Warning Systems) case of the Philippines
- Introduction of Water Level Equipment for Water Disaster management System/River management System- Case of Flood Sensors (image type)
- Installation Works of the Pressure type water level and staff Gauges under JICA TCP sensors in 2011.

5. Results

Capacity building on types of level gauges and flood risk management was presented to the HQ and Regional staff with the aim of.

- Improve WRA Staff skills in selecting equipment for observation and data transmission.
- At least 16 staff members of WRA were available for training and followed through to the end.
- Equip the WRA staff with alternative and effective risk management related to floods.
- Equip WRA staff on optimising and using appropriate technology that positively impacts quality and effectiveness.

6. Findings & Discussions

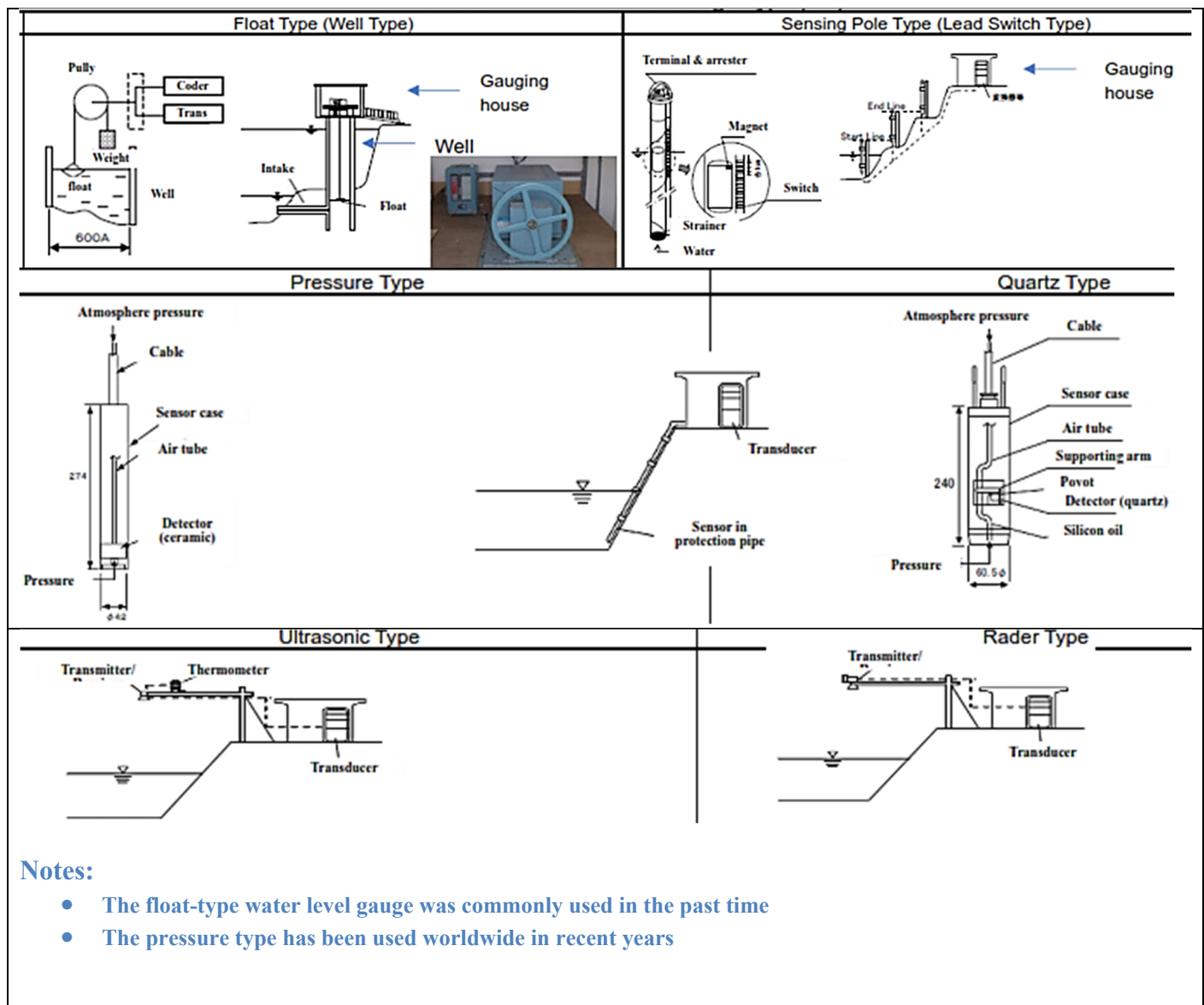
- Operational challenges were identified, such as missing data for existing telemetric stations.
- Additional capacity building on telemetric and automatic raw data handling archiving quality check and analysis.
- Review of Data Management Plan with combined or multiple WL gauge facilities for time series

generation.

- Data equipment is prone to vandalism, especially in remote locations.
- Similarly, any major maintenance is sought from the head office.
- Regional and subregional offices perform essential station maintenance.

***More training shall be scheduled in the coming months.

Examples of Diverse Instruments Housing Sensors for Water Level Observations.



Installation Example 1: Sensing Pole Type

Gauging station	Support for water level sensor
	
LeTelecom room	These equipment were constructed in 1980's years and some of the equipment were deteriorated due to expire of equipment life (approx. 20-30 years), however some equipment are still operational after 30 years in 2011 because good and proper maintenance works have conducted by an operator (periodic maintenance works, 3 months interval in a year)
	

Lessons learned:

- Proper maintenance works can extend the length of equipment life
- Trainings to conduct the proper operation and maintenance (O&M) works are essential
- Such requirements shall be added to a contract for procurement of equipment and select good vendor(s)/manufacturers

5

Water Disaster Management System and River Management System

Function and specifications

① Non-contact measurement with image

- Water boundary is read as water level with image analysis from reflection panel

② Easily setting

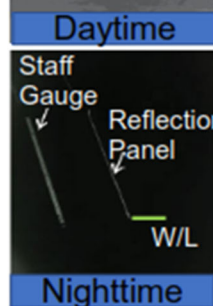
- All-in-one box
- wireless communication system
- Solar panel

③ Measurements for nighttime and heavy rain

- Stable measurement
- Air wiper

④ Low cost

- Target price is 1 million JPY (KES907,847)

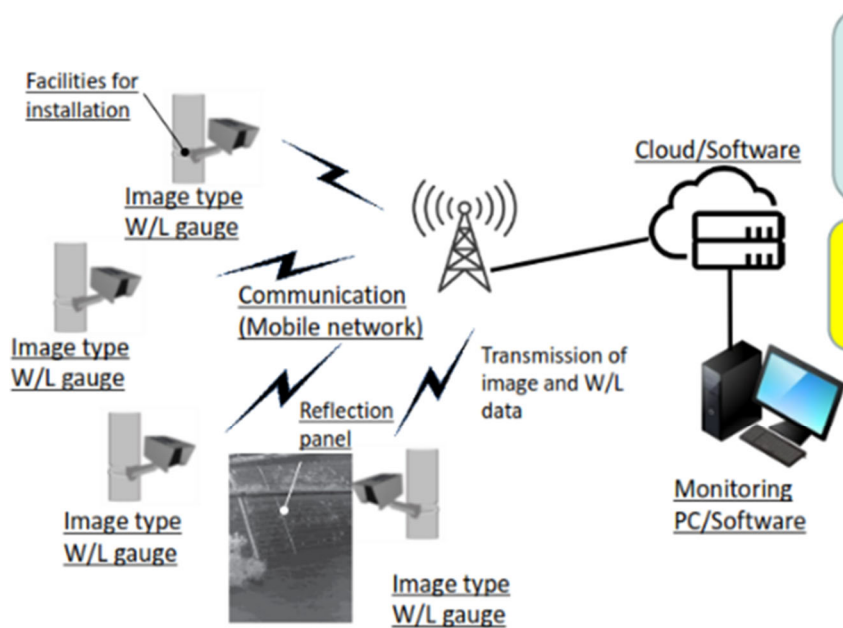


All-in-one
Easily Setting

Notes:

- The Instrument can detect Water Level automatically
- The Instrument can detect Water Levels from pictures taken.
- Economical to operate and provides two alternatives for water level measurement.

System Configuration



Challenges

- The water levels are read by manual
- It is difficult to monitor/read the measuring data during night-time, fog and rain.

Solution

Water level gauge reading by AI (Automatic)

Notes:

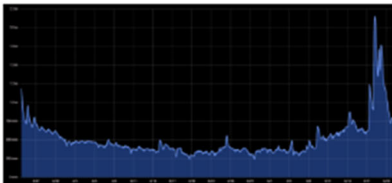
- This system is developed to measure at night time and heavy rain with automatic measurement

Water Level Sensor for Risk Management

Ultra-Sonic type sensors



Item	Specifications
Box	IP-55
Weight of Box	<2 kg
Dimensions	125 (W) x 229 (H) x 124 (D) mm
Power	Lithium Battery for 5 years operation
Method of measurement	Ultrasonic Wave
Range	0.6 to 8 m
Accuracy	+/- 1 cm with 1 mm resolution
Telecommunication system	LPWA (LTE Cat.1)



This equipment is developed to accomplish a low cost with compact design, and easy installation, particularly for small to mid-sized rivers

Water level data is monitored real-time

functions and specifications

① Flood Sensor

- Compact and lightweight, can be installed anywhere
- Battery powered for 2 to 5 years



② Aggregate Router

- Communication with multiple sensors
- Commercial power supply or solar panel supply
- Cloud server

③ Realtime Monitoring Flooded Area

- Flood can be detected through on/off Bluetooth signal in real time (When water touch Bluetooth tip, it become off)
- Browsing on smartphone as well as office PC



Notes:

- These equipment are developed to aim for cost reduction

List of Participants

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22	Eugene Mwandoe	Communication Expert	Nippon Koei	emnyamwezi@gmail.com

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JICA_WRA Activities _PRESENTATION 12th January 2023

Request control

People Chat Reactions More

Camera Mic Share Leave

JH RN PM A M GC

Jared Otieno... reuben nge... patricia mu... azuma (ゲスト)... Masika (G... ABDI OMAR (G... KENNEDY... Jane wai... Samuel Nd... Jackline- E... DOREEN (G... Eugen Me...

Selection of Water Level Gauge Type and Introduction the FFWS Project in the Philippines

Yasushi Azuma
NIPPON KOEI CO., LTD.

Installation Works of the Pressure Type Water Level and Staff Gauges under JICA TCP in year 2011

Introduction of Water Level Equipment for Water Disaster Management System/ River Management System

January 12, 2023
Nippon Koei Co., Ltd.
Kenya Water Resources Advisor

Participants

Type a name

Share Invite

In this meeting (20)

Mute all

GC Gilbert Chamo Organizer

AD ABDI OMAR (Guest)

A azuma (ゲスト) (Guest)

D DOREEN (Guest)

DR Dr. Lee Baraza (Guest)

ES Eric Busiega

EM Eugen Mwandoe (Guest)

EM Eugen Mwandoe (Guest)

FM Faith Mbathi (Guest)

JL Jackline- Embu (Guest)

JN Jane Wairimu Njoroge (Guest)

JN Jared Otieno-WRA HQ (Guest)

JM Josiah Maina Waboyo

K KENNEDY OCHIENG

M Masika (Guest)

M Morgan Oryango

PM Patricia Musau (Guest)

PM reuben ngesa



Kenya Water Resources Advisor JICA Experts Team

No.7 (May 2023)

Newsletter No.7

In May 2023, the seventh field work was conducted, with three Japanese Experts and four national staff. This newsletter describes the project activities carried out during this period and the outcome achieved.

1. Project Background

A study of "National Water Master Plan 2030 (NWMP 2030)" was conducted by Water Resources Management Authority (WRMA: former governmental agency now renamed WRA) as the executing agency with the assistance of Japan International Cooperation Agency (JICA) during the period from October 2010 to November 2013. The study supported the formulation of water resources development and management plans for all six basin areas in the country as well as the formulation of action plans for strengthening water resource management capacity.

In 2017, aiming at strengthening of water resource management based on appropriate monitoring, JICA implemented activities of "JICA Expert for Water Resources Management" from January 2017 to September 2019. Various activities were implemented such as discharge measurement and installation of water level gauges, which contributed much to the capacity building of WRA staff in its headquarters, Tana Regional Office as well as other five regional offices. However, it is further required to level up the capacity of WRA staff, so that they are able to achieve early implementation of plans formulated by NWMP 2030 and to perform the tasks stipulated in the new Water Act 2016.

As a follow-up, the 'Kenya Water Resources Advisor Team' was constituted to strengthen water resources management skills for WRA staff in the Tana Basin area for the period April 2021 to April 2024. Among the activities under implementation include discharge measurement, river cross-sectional profiling, preparation of the H-Q curve, analysis of climate change effects, and operation and management of the database.

2. Activities

This newsletter highlights the hydrological activities undertaken in May 2023, which focuses on discharge measurement and river cross-section survey at the three stations; Kathita 4F10, Sagana 4AC03, and Rupingazi 4DC03. A one-day seminar for capacity building on Water Resources Management was carried out by the JICA team to enhance knowledge of the Surface Water Officers.

3. Site visits

Visit to Embu Regional Office

On 10th May 2023, one Japanese Expert and two national staff visited the regional office (RO) with a view to appraising the Office on the status of the project and plan for the current activities. The highlights of the issues discussed include:

- The Expert team along with the JICA officers from its Head office to meet the WRA CEO to update on the status of the project implementation.
- The JICA Expert Team to work closely with the Blue Deal project to address common program areas and share lessons learned during program implementation.
- It was noted that with the implementation of the new tariffs, WRA is expected to raise more revenue for improved data collection and quality service delivery.
- Formalize arrangements for a one-day training workshop on discharge measurement and river cross-section profile.
- A total of 15 technical officers were proposed to attend the training.

Visit to Thiba, Murang'a and Meru SROs

On 4th May 2023 JICA Team paid a courtesy visit to Murang'a and Thiba Sub-Basin offices and on 11th May 2023, they visited Kathita-Mutonga Sub-Basin Office. The objective was;

- Share the project's progress report
- Agree on planned activities
- Confirm the availability of counterpart staff for the scheduled activities.
- Carry out a reconnaissance visit to River

Rupingazi (4DC03), Sagana (4AC03), and Kathita (4F10) to assess the river water level for planning purposes.

Discharge Measurements

On 18th May JICA Experts Team together with WRA officers from Meru Sub Region Office visited Kathita 4F10 and jointly carried out the discharge measurement and river cross-section survey. The water levels were high and hence a boat was used to wade across the river. The exercise was successfully done achieving both discharge measurement and the cross-sectional profile at the station.



Photo 1: Dr. Masika, Ms. Doreen, and Mr. Gordon carrying out the cross-sectional survey at 4F10 using a boat



Photo 3: Ms. Doreen, Ms. Jane (SWO, Upper Tana sub-basin) and Dr. Masika carrying out discharge measurement at 4AC03



Photo 4: Dr. Masika, Ms. Doreen and Ms. Jane (SWO Thiba Sub-basin) during discharge measurement at 4DC03

4. Result of the Exercise

Observed discharge volume (1st/2nd time)

RGS	1 st measureme ntnt(m ³ /s)	2 nd measureme ntnt(m ³ /s)	% Difference
4DC03	4.64	4.60	0.85
4CA03	7.97	-	-
4F10	10.36	10.98	5.64

5. Key Findings from the Exercise

1. The process of discharge measurement has improved as demonstrated by the consistency of results from the exercise. This has led to a reduced percentage error term between measurements at a station to less than the targeted 10% compared to the initial error term that was as high as 23.7%.
2. During May 2023 season, discharges in the target rivers were high owing to the rainfall received in the basin. The discharge measurement exercise was achieved using the propeller-type current meter by wading method in Sagana 4AC03 and Rupingazi 4DC03 and using a boat in Kathita



Photo 2: Dr. Masika and Mr. Gordon using the propeller-type current meter during discharge measurement while Ms. Doreen taking the bookings at 4F10



On 23rd May 2023 JICA Experts Team visited the Murang’a and Thiba sub-basins to undertake discharge measurement and the river cross-section survey at Sagana 4AC03 and Rupingazi 4DC03 respectively. A local volunteer was engaged to assist in wading across the river during the survey as the water level was high.

4F10 at the RGS. This reduced reliance on ADCP which is currently out of order.

The water level data sets in the database at the Sub- basin are not up-to-date. Similarly, data gaps are prevalent in the database occasioned by a lack of facilitation to collect the data sets from gauge readers, washed away or vandalized gauges, absence of gauge readers.

6. Way Forward

The next exercise is scheduled for October 2023 before the onset of short rains.

7. Lessons

- The dependency on the ADCP for high-flow discharge measurement can be overcome by considering the use of available current meters and the boat.
- The level of proficiency in the use of propeller type current meter amongst the Surface Water officers has greatly improved.
- Frequent engagement with management and staff has greatly improved the working relationship.
- The data base has currently configured contains multiple paths to various data sites with similar names which may be confusing to officers while uploading data.

8. Capacity Building on Water Resources Management

In accordance with the project's work plan, the JICA Expert team organized a one-day seminar for capacity building majorly related to Surface water. It was held on 30th May 2023 at the Embu Regional office. The main targeted participants were the Surface Water Officers in Upper Tana Region. The seminar was also held virtually for officers from Garissa and Kitui. Mr. Kato and Mr. Masika were the main facilitators. Topics discussed include:

- Reading water level at the gauge
- Recording the data accurately
- Maintenance of the gauges
- Importance of proper data observation, arrangement, and storage

Additionally, Ms. Pauline (Surface Water Officer Embu) taught other officers how to effectively enter data on the MIKE-INFO platform for easy analysis. She highlighted the uploading and data storage on the platform.

After the presentations, Practical lessons on discharge measurement and cross-sectional survey were carried out at 4DC03 Rupingazi.



Photo 5: Mr. Kato presenting on procedures undertaken during discharge measurements



Photo 6: Dr. Masika Presenting on Data gaps and data Analysis



Photo 7: Ms. Pauline showing the officers effective ways of uploading data on the system



Photo 8: Practical lessons on Discharge measurement and cross sectional survey at 4DC03



Kenya Water Resources Advisor JICA Experts Team

No.8 (November 2023)

Newsletter No. 8

The eighth field work was conducted from October to November 2023 by three Japanese experts and four national staff. The newsletter describes the project activities carried out during this period and the outcome achieved.

1. Project Background

A study of "National Water Master Plan 2030 (NWMP 2030)" was conducted by Water Resources Management Authority (WRMA: former governmental agency now renamed WRA) as the executing agency with the assistance of Japan International Cooperation Agency (JICA) during the period from October 2010 to November 2013. The study supported the formulation of water resources development and management plans for all six basin areas in the country as well as the formulation of action plans for strengthening water resource management capacity.

In 2017, aiming at strengthening of water resource management based on appropriate monitoring, JICA implemented activities of "JICA Expert for Water Resources Management" from January 2017 to September 2019. Various activities were implemented such as discharge measurement and installation of water level gauges, which contributed much to the capacity building of WRA staff in its headquarters, Tana Regional Office as well as other five regional offices. However, it is further required to level up the capacity of WRA staff, so that they are able to achieve early implementation of plans formulated by NWMP 2030 and to perform the tasks stipulated in the new Water Act 2016.

As a follow-up, the 'Kenya Water Resources Advisor Team' was constituted to strengthen water resources management skills for WRA staff in the Tana Basin area for the period April 2021 to April 2024. Among the activities under implementation include discharge measurement, river cross-sectional profiling, preparation of the H-Q curve, analysis of climate change effects, operation and management of the database.

2. Activities

This newsletter highlights capacity building activity undertaken in October 2023 which focused on (Hydrological data processing, analysis, preparation

and development of rating curves, and analysis on the impact of climate change). Hydrological activities were scheduled for November 2023 to measure discharge and river cross section surveys at the three stations: Kathita 4F10, Sagana 4AC03, and Rupingazi 4DC03. Field visit to proposed pilot stations for Water Allocation Planning and Flood Early Warning Frameworks for upper Tana Gura - Sagana Management Unit was also carried out.

2.1 Capacity Building

On 12th-13th October 2023 JICA Team held a capacity building seminar for Tana Basin surface water, licensing, community development and ICT officers at Tana Regional offices in Embu. Areas of focus during the seminar included:

- Hydrological Data processing: Data pre-processing (gap filling, verification etc.), Data analysis (preliminary analysis– Rainfall vs discharge graph; scatter plots, trend line and interpretation).
- Frequency analysis of Hydrological data: frequency analysis of extreme events such as high flow and low flow, and practical application–hands on using excel.
- Preparation and development of rating curves areas covered are; hydrological concepts and use of rating curves, challenges associated with the use of flow rating curves and practical session for rating curve development.
- Analysis flow of the climate change impact.
- Discussion on telemetering stations for capacity building and optimization of network; overview of WEAP/MIKE zero adaptor tools for Water allocation plan (WAP) for pilot sub-basins.



Photo 1: Dr. Masika presenting on Hydrological data processing, frequency analysis, preparation and development of rating curves.



Photo 2: Mr. Mwandoo presenting on telemetric stations and MIKE adaptor tools for WAP formulation



Photo 3: Mr. Okamura presenting on analysis flow of the climate change impact



Photo 4: Mr. Chumo presenting report on collaboration with other partners and WEAP Results for selected sub-catchments from available data.



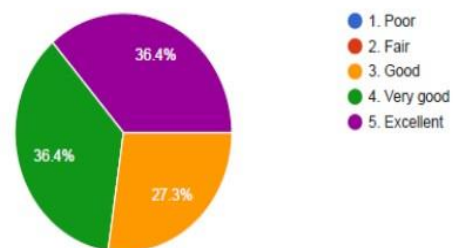
Photo 5: Practical session with the participants

2.2 Feedback from Capacity building workshop

The hydrological analysis was the most valuable information, but it was also a challenging topic for the participants. In particular, data processing and analysis, development of rating curves and their relationship with the cross sectional profile, WEAP, and MIKE Suites application in basin water balance. However, participants indicated the need for further training with a preference for more hands-on sessions to enhance understanding of the concepts. Some of the feedback received from the participants include:

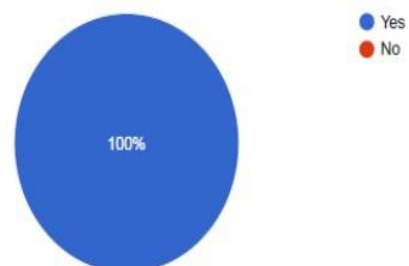
1. On a scale of 1 to 5, how would you rate the overall quality of the seminar?

11 responses



2. Did the Capacity Building seminar meet your expectations?

12 responses



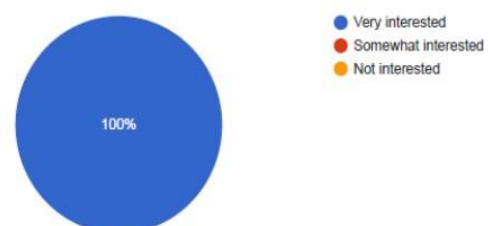
4. What was the most valuable or informative aspect of the seminar for you?

10 responses

Hydrological analysis of flow levels.
Development of rating curves
Importance of Data cleaning
The importance of getting actual data i.e for the months with 28,29,30,31 days
Determination of flow duration curve and coloration of RGS stations
Frequency analysis for extreme events of floods and drought
Practical session for developing rating curve
Data analysis
Frequency analysis using Excel
Data pre processing

10. In future Would you be interested in participating in training or workshops focused on hydrological data processing and analysis?

12 responses



2.3 Site Visits

2.3.1 Visit to Embu Regional office

On 1st November 2023, one Japanese Expert (Mr. Ueda) and three national staff visited the Tana Regional office with a view of appraising the office on the status of the project and plan for the current activities. Issues discussed include:

- Introduction of Mr. Ueda as the project Hydrologist to replace Mr. Kato.
- Request was made to the JICA Team for support in data collection, water balance assessment and water allocation planning.
- It was proposed that the regional staff especially the Surface Water Officer should be considered to accompany JICA-WRA missions for effective reporting of project activities at the Regional and to the Headquarter offices.

2.3.2 Visit to Thiba, Upper Tana, and Kathita SRO's

On 1st November 2023, the JICA Team visited Thiba sub-basin office, they then visited the Upper Tana sub-basin office on November 2nd, and the Kathita-Mutonga sub-basin office on November 3rd 2023. The objective was:

- Introduce Mr. Ueda as Mr. Kato's replacement to the relevant officers at the sub-basins.
- Share updates on the project's activities.
- Discuss and agree on the planned activities.
- Confirm availability of counterpart staff for the scheduled activities.
- Carry out reconnaissance visit to RGS Rupingazi (4DC03), Sagana (4AC03), and Kathita (4F10).

On 15th November 2023 two Japanese Experts (Mr. Ueda and Mr. Azuma), one national staff and Murang'a sub-regional office surface water officer visited four stations 4AC03, 4BB01, 4BC02 and 4BE01 as the proposed pilot stations for Water Allocation Planning (WAP) and Flood Early Warning System (FEWS) for upper Tana Gura - Sagana Management Unit. The purpose of the visit was to appraise the team on the operational status of the stations and also to determine data availability in real time as well as historical data for the purposes of building capacity modules for WAP and FEWS.

STATION	STATUS
4AC03 Sagana	An automatic weather station fitted with a water level measuring sensor. It is operational and transmitting real time data to Meteorological Department.
4BB01 Ragati	Station vandalized however real time data before vandalism is available at WRA Headquarters.
4BC02 Tana at Sagana	Station not accessible during the visit, it was fenced but the door was intact. The team later confirmed it was operational and transmitting data in real time.

STATION	STATUS
4BE01 Maragua	One SEBA telemetric station and a HOBO data logger have been installed and are both operational. Data from the SEBA station is transmitted in real time to WRA Headquarters. The HOBO station is regularly downloaded by the sub-region office.



Photo 6: 4BB01 Station found vandalized. Staff gauge reading under the bridge was 1.10M at 1:06PM.



Photo 7: Gauging station 4BE01

(HOBO) on 15/11/2023



Photo 8: Gauging station 4BE01 (SEBA) on 15/11/2023

2.3.3 Observations

The team noted that:

-The telemetric stations are well distributed in proposed pilot sub-basin for formulating a WAP process as well as template for early warning to address local flooding and drought conditions through combined utilization of real or near real time data from the Automatic Weather Station (AWS) and river flow stations.

-The status of the data from the stations needs to be confirmed through collaboration with WRA and other partners operating in the basin.

-The issue of vandalism of stations is rampant and it is compromising integrity of telemetric network objective for real time data acquisition.

In this regard, it is recommended that:

-Requisite real time and historical data of the stations to be availed to the JICA Team to assist in the preparation of hands-on training modules for WAP and FEWS.

- The issue of vandalism needs to be addressed through collaboration with community and local administration

2.4 Discharge Measurements

The activity was scheduled to take place from 8th-10th November 2023 at the three target stations. However, the high amount of rainfall received in the Tana Basin caused significant rise of water levels in the rivers. On 8th November 2023, discharge measurement at River Sagana 4AC03 was not possible due to high water level and velocity, that made it impossible to use the boat.

The Meru and Kerugoya Surface Water Officers confirmed high water levels in Kathita 4F10 and Rupingazi 4DC03 respectively. Consequently, the planned activities had to be rescheduled to (22nd-24th November 2023) with the anticipation of decreased rainfall amounts received in the basin within the two-week period.

On November 22, 2023, the team attempted to carry out the scheduled activity for the second time at Sagana 4AC03. However, heavy rainfall was still pounding the sub-basin resulting to further increase in river flows. A similar situation was observed in Rupingazi 4DC03 and Kathita 4F10.



Photo 9: Submerged gauge at Sagana 4AC03 on 22/11/2023 at 11:20am. Water level above 1.5M

Due to safety concerns the mission was postponed for the second time.

In the afternoon, the Team together with Ms Jane from Thiba sub-basin visited Rupingazi 4DC03 to check on its status and the water levels were too high and so was the velocity.



Photo 10: 4DC03 Water level at 1.30M on 22/11/2023 at 1:50pm

The activity was postponed for the second time due to safety concerns. On 23rd November 2023, the team together with Mr. Kimotho of Meru sub-basin visited Kathita 4F10 and the situation was the same as the other two stations in Sagana and Rupingazi.



Photo 11: 1st gauge completely submerged. 2nd gauge readings at 1.5M

The discharge and cross section profile measurement were not undertaken and postponed to a later date.

3. Way Forward

Due to high water levels and velocity in the rivers, the hydrological activities are rescheduled to February 2024 with an anticipation that the rains will have subsided in the Tana Region.



Kenya Water Resources Advisor JICA Experts Team

No.9 (February 2024)

Newsletter No. 9

The ninth fieldwork was conducted in February 2024 by two Japanese experts and three national staff. The newsletter describes the project activities carried out during this period and the outcome achieved.

1. Project Background

A study of "The National Water Master Plan 2030 (NWMP 2030)" was conducted by the Water Resources Management Authority (WRMA: former governmental agency now renamed WRA) as the executing agency with the assistance of Japan International Cooperation Agency (JICA) during the period from October 2010 to November 2013. The study supported the formulation of water resources development and management plans for all six basin areas in the country as well as the formulation of action plans for strengthening water resource management capacity.

In 2017, aiming at strengthening water resource management based on appropriate monitoring, JICA implemented activities of "JICA Expert for Water Resources Management" from January 2017 to September 2019. Various activities were implemented such as discharge measurement and installation of water level gauges, which contributed much to the capacity building of WRA staff in its headquarters, Tana Regional Office as well as other five regional offices. However, it is further required to level up the capacity of WRA staff, so that they can achieve early implementation of plans formulated by NWMP 2030 and to perform the tasks stipulated in the new Water Act 2016.

As a follow-up, the 'Kenya Water Resources Advisor Team' was constituted to strengthen water resources management skills for WRA staff in the Tana Basin area for the period April 2021 to April 2024. Among the activities under implementation include discharge measurement, river cross-sectional profiling, preparation of the H-Q curve, analysis of climate change effects, operation and management of the database.

2. Activities

This newsletter highlights the hydrological activities undertaken in February 2024 which focuses on discharge measurement and river cross-section survey at the three stations; Sagana 4AC03, Rupingazi 4DC03 and Kathita 4F10.

A one-day seminar for review session on discharge measurement and river cross-section survey results was held at the Embu Regional office on February 14, 2024.

3. Site Visits

Visit to Embu Regional Office

On 7th February 2024, a courtesy visit was made to the regional office by two Japanese Experts and two national staff. The highlights of the visit were:

- Introduction of Mr. Okada as the replacement for Mr. Ueda.
- The JICA Experts Team reported that it intends to undertake the fourth and last activity for discharge measurement and river cross-section survey. It was noted that the November mission failed due to very high flows caused by the El Nino rains.
- The team informed the office of the review session for the four times measurements that was scheduled for the 14th February 2024.
- It was agreed that Mr. Ndung'u (Surface Water Officer Embu) was to join the team during the Rupingazi activity.
- Mr. Joram (Water Quality & Pollution Officer) requested the team to take water samples during the exercise.

Discharge Measurements and River Cross section survey

On February 7, 2024 (afternoon) the team together with Ms. Jane Wairimu Njoroge, surface water officer Murang'a visited 4AC03 Sagana and jointly carried out discharge measurement and river cross-section survey. The exercise was successfully done, and the objectives of the activity were met.



Photo 1: Mr. Okamura, Mr. Okada, and Ms. Jane Wairimu Njoroge during Cross-section survey at 4AC03 Sagana

On February 9, 2024, the team and Mr. Kimotho (Surface Water Officer, Meru) went to 4F10 Kathita to conduct the same exercise. River cross-section survey and discharge measurement were conducted jointly. Because the water levels were high (the deepest point being 1.7M), a boat was necessary. Similarly, a local swimmer was engaged to tie the anchorage rope across.



Photo 5: Mr. Kimotho, Ms. Millicent and Mr. Okada performing the cross-section survey at 4F10 Kathita.



Photo 2: Ms. Jane Wairimu Njoroge, Ms. Doreen and Dr. Masika carrying out discharge measurement at 4AC03.

In 4DC03 Rupingazi, the team together with Ms. Jane and Mr. Ndung'u Surface Water Officer Kerugoya and Embu respectively performed the exercise on 8th February 2024. An anchorage rope across the river was tied with the assistance of a local.



Photo 3: Ms. Jane Njuguna taking readings during cross-section survey at 4DC03 Rupingazi.



Photo 6: Mr. Gordon, Ms. Doreen, and Dr. Masika carrying out discharge measurement using a propeller-type current meter in a boat at 4F10.

4. Results of the exercise

RGS	1st measurement (m ³ /s)	2nd measurement (m ³ /s)	% Difference
4AC03	5.6	4.79	14.46
4DC03	2.5	2.49	0.4
4F10	12.04*		

*Only one measurement taken at 4F10

5. Key findings from the Exercise

1. The counterpart staff have consistently maintained their proficiency as indicated by the consistent results for the stations' discharge and cross-section profiles.
2. The cross-sectional profile of the Rupingazi (4DC03) and Sagana (4AC03) rivers are usually stable, except for some scoring on the left banks of both rivers. However, the Kathita 4F10 profile varies due to bed erosion and deposition during and after flows.



Photo 4: Mr. Ndung'u, Dr. Masika and Ms. Doreen Carrying out discharge measurement at 4DC03

3. It is desirable to use a common field booking sheet that combines discharge measurement and cross-section profile. This is significant for the discharge-gauge height ratings and extrapolation during high flows.

6. Review session for Discharge Measurement and River Cross section survey

On February 14, 2024, the JICA Experts Team held a review session for discharge measurement and river cross-section survey at the Tana Basin Office in Embu and the target was Surface Water Officers in the Tana Basin offices (Kerugoya, Murang’a, Embu, and Meru), other officers from the regional office who were interested in to participate in the session were also invited. The main focus of the session included:

- Outline of Discharge Measurement Activities:
Explanation of the purpose of activities and outline of survey and measurement activities.
- Method of Discharge Measurement:
Explanation of the measurement methods, Results survey, and measurement of activities.
- Explanation of measured Discharge Calculation and Exercises:
Explanation on calculation sheet exercises using calculation sheet with MS Excel.
- Presentation on the Discharge Calculation Results.
- Discussion on Required Resources of Discharge Measurement and River Cross Section Survey.



Photo 7: Mr. Okamura presenting the outlines of Discharge Measurement activities.



Photo 8: Mr. Okada presents on method of Discharge measurement.



Photo 9: Training session for rating curve development by Dr. Masika.



Photo 10: Practical session with participants. (Hands-on practice exercise using calculation sheet with MS Excel.)



Photo 9: Ms. Jane Wairimu Njoroge expressed her sentiments on the review session on behalf of the surface water officers present.
Photo 10: Ms. Jackline Mutinda giving her closing remarks.



6. Lessons

Regularly monitoring the cross-sectional profile of all rivers is vital for updating rating curves more frequently based on their constantly changing profiles. Kathita River in 4F10 is particularly variable, which requires close monitoring along with other channels of the same kind.

A field booking sheet that combines discharge measurement and cross-section profile into one convenient form should be considered by WRA. This could be beneficial for future comparison of the profiles at the regular gauging stations which could save the staffan inordinate deal of time and energy.

7. Way Forward

Next stay of JICA experts will be from mid-May to June 2024. During that time, they will conduct scheduled activities in the project.



Kenya Water Resources Advisor JICA Experts Team

No.10 (June 2024)

Newsletter No. 10

The ninth fieldwork was conducted in May and June 2024 by two Japanese experts and four national staff. The newsletter describes the project activities carried out during this period and the outcome achieved.

1. Project Background

A study of "The National Water Master Plan 2030 (NWMP 2030)" was conducted by the Water Resources Management Authority (WRMA: former governmental agency now renamed WRA) as the executing agency with the assistance of Japan International Cooperation Agency (JICA) during the period from October 2010 to November 2013. The study supported the formulation of water resources development and management plans for all six basin areas in the country and action plans for strengthening water resource management capacity.

In 2017, aiming at strengthening water resource management based on appropriate monitoring, JICA implemented "JICA Expert for Water Resources Management" activities from January 2017 to September 2019. Various activities were implemented such as discharge measurement and installation of water level gauges, which contributed much to the capacity building of WRA staff in its headquarters, Embu Regional Office as well as five other Regional Offices. However, it is further required to level up the capacity of WRA staff so that they can achieve early implementation of plans formulated by NWMP 2030 and to perform the tasks stipulated in the new Water Act 2016.

As a follow-up, the 'Kenya Water Resources Advisor Team' was constituted to strengthen water resources management skills for WRA staff in the Tana Basin area for the period April 2021 to April 2024. The activities period was further extended up to October 2024. Among the activities under implementation include discharge measurement, river cross-sectional survey, preparation of the H-Q curve, analysis of climate change effects, and operation and management of the database.

2. Activities

This newsletter highlights the capacity-building activities undertaken in June 2024, which focused on the analysis and utilization of hydrological and meteorological data.

A technical meeting was held on June 4, 2024, between the JICA Team and Kenya Meteorological Department (KMD) that focused on numerical weather forecasting, flood early warning in the Tana Basin, data sharing issues, and model outputs, emphasizing collaboration and data exchange.

A one-day seminar training on Frequency analysis of rainfall and flow, analysis of recent rainfall Patterns, Hydrological cycle characteristics, and projected climate change impacts around Tana Basin was presented at the Embu Regional office on June 10, 2024. The details of the visit were reported as follows:

2.1 Site Visits

Visit to Kenya Meteorological Department

On 4th June 2024, a courtesy visit was made to the Kenya Meteorological Department (KMD) by the JICA Experts Team. The highlights of the visit were as follows:

- KMD prepares daily and weekly Forecasts by running numerical weather prediction models to provide essential weather forecasts.
- Key weather parameter model outputs include precipitation, temperature, wind speed and direction, and cloud cover data.
- Data Sharing Policy: KMD shares processed data upon request; raw data is restricted.

Training Session at Embu Regional Offices

On 10th June 2024, a training session covered frequency analysis, flow duration curves, flood frequency analysis, and low flow frequency analysis.

The session emphasized the importance of these analyses for predicting event probabilities and highlighted limitations related to data quality and hydrological assumptions.

- **Frequency Analysis:** Describes the likelihood of events like floods, using return periods or exceedance probabilities.
- **Flow Duration Curves:** Illustrate the percentage of time-specific discharges that are exceeded, indicating flow regime characteristics.
- **Flood Frequency Analysis:** Focuses on peak flows and recurrence intervals, using annual maximum or partial duration series.
- **Low Flow Frequency Analysis:** Quantifies the probability of low flows over specific durations, crucial for water resource management.
- **Analysis Limitations:** Accuracy depends on the quality of streamflow records, assumptions of event independence, and static hydrological regimes.

Mr. Okada conducted a train on frequency analysis of rainfall and flow, with particular emphasis on the Tana Basin. Key topics included rainfall patterns, hydrological cycle characteristics, and the projected impacts of climate change. The session provided insights into:

- **Outline of April 2024 Flood:** Detailed analysis of the flood event, including its causes and impacts.
- **Mechanism of Rainfall:** Understanding how rainfall is generated and its distribution patterns.
- **Climate Variability around Eastern Africa:** Examination of regional climate patterns and their variations.
- **Future Climate Risk:** Assessing potential future risks due to climate change and strategies for mitigation.

The session covered tasks related to Output 4 on Capacity Building on Analysis and Utilization of Hydrological and Meteorological Data. Training on annual maximum series (AMS) modeling procedures for frequency analysis was also provided.



Photo 1: Discussions at KMD office. Illustration by KMD staff on methods applied in weather forecasting.

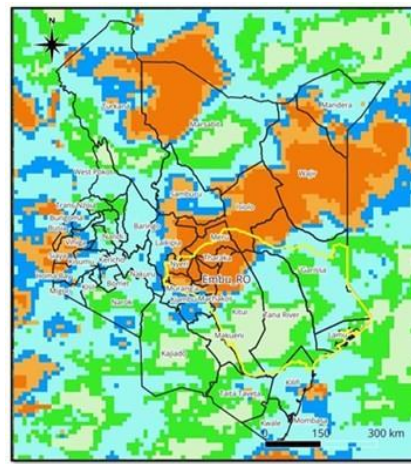


Figure 1: Illustration of Rainfall Distribution during April Floods in Kenya using GSMaP_MVK



Photo 2: Training session by Dr. Masika on Frequency Analysis



Photo 3: Mr. Okada presenting on rainfall distribution, floods, and climate change impact.

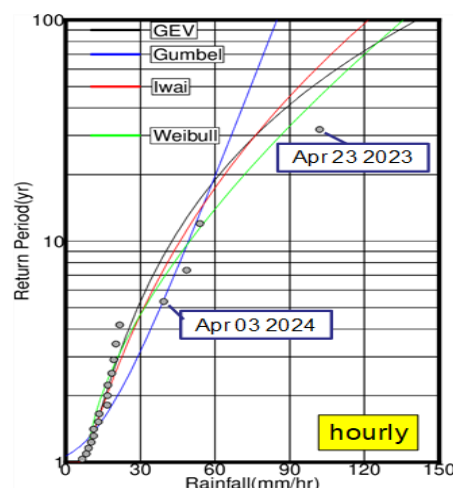


Figure 2: An Example of frequency analysis using hourly rainfall near Embu on GSMaP MVK.



Photo 4:
Group Photo
with Tana
Regional
Staff

3. Propose the implementation of a prototype of a flood forecasting model in the Tana Basin.

3. Key findings from the Exercise

1. Rainfall data: Japanese Aerospace Exploration Agency(JAXA) provides satellite-based rainfall products called GSMaP free of charge.
2. Seasonal rainfall: This is due to the Intertropical Convergence Zone (ITCZ) movement caused by the earth rotation.
3. Climate variability insights: Understanding climate impacts helps in sustainable water resource planning and management.
4. Flow analysis: Tools like flow duration curves help design resilient infrastructure and inform water allocation.
5. Frequency Analysis: It is highly dependent on the results of daily monitoring, and that daily monitoring, quality control, and data storage are extremely important.

4. Lessons

The training highlighted crucial lessons from frequency analysis, emphasizing its role in predicting flood and drought events, the importance of understanding flow duration curves for water resource management, and the necessity of reliable and long-term streamflow records for accurate frequency analysis.

Integrating these statistical techniques can significantly improve water resource planning and management, aiding in the development of resilient systems against extreme hydrological events.

5. Way Forward

1. The next JICA Experts activity will be from mid-July to early August 2024. During this time Telemetering Expert Mr. Azuma will conduct capacity building on observation and data transmission facilities which covers activity 2-3 of the project.
2. From the end of August to September 2024, the final activity of the JICA Experts Team will be conducted. During this period two main Seminars are scheduled to be held in Embu (September 17, 2024) and in Nairobi (September 19, 2024).



Kenya Water Resources Advisor JICA Experts Team

No.11(July 2024)

Newsletter No. 11

A part of the ninth fieldwork was conducted in July 2024 by one Japanese Expert and four national staff. The newsletter describes the project activities carried out during this period and the outcome achieved.

1. Project Background

A study of "The National Water Master Plan 2030 (NWMP 2030)" was conducted by the Water Resources Management Authority (WRMA: former governmental agency now renamed WRA) as the executing agency with the assistance of Japan International Cooperation Agency (JICA) during the period from October 2010 to November 2013. The study supported the formulation of water resources development and management plans for all six basin areas in the country and action plans for strengthening water resource management capacity.

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As a follow-up, the 'Kenya Water Resources Advisor Team' was constituted to strengthen water resources management skills for WRA staff in the Tana Basin area for the period April 2021 to April 2024. The activities period was further extended up to October 2024. Among the activities under implementation include discharge measurement, river cross-sectional survey, preparation of the H-Q curve, analysis of climate change effects, and operation and management of the database.

2. Activities

This newsletter highlights the capacity-building activities undertaken in July 2024 which focused on water resources real-time telemetric equipment, data acquisition, and management.

2.1 Capacity Building

On 24th– 26th July 2024, the JICA Experts Team, in collaboration with WRA officers from the Headquarters in Nairobi held a capacity-building seminar that targeted the Tana Basin Surface Water and I.C.T officers which was held at the Tana Basin Office in Embu. Areas of focus during the training included:

- Introduction to Mike Workbench Graphical User Interface (Database connectivity): Demonstrates the functionality of available Graphical user interface log-in connectivity to installed databases objects, explorers, properties, and tools for data manipulation and exchange.
- Field Equipment Installation (SEBA and Data logger communication): Providing an overview of telemetric equipment that supports real-time data acquisition, transmission, and requisite settings in the data logger depository.
- Telemetric equipment in Japan (best practices): Demonstrates best practices for real-time operation of telemetry systems in Japan.

- Hands-on exercise on the installation of Mike workbench and Mike Zero Software: Provides practical hands-on experience in the installation of the software by participants.
- Introduction to Mike Hydro Schematic for Pilot study area: Provides practical experience in the development of Mike Zero Project Schematics in preparation for model registrations hydrodynamic modeling of rivers and basins.
- Populating Mike Schematic, transfer to Mike Workbench and Model setup: Illustrates filling model object parameters, basin properties, characteristics, and time series visualization of the same and transfer schematic to Mike Workbench for model setup.
- Discussion and questions on quality control and Assurance (Maintenance, missing data, and filling data gaps): An interactive session encourages feedback from participants on the training, challenges, and gaps in the knowledge transfer.



Photo 3. Mr. Azuma (JICA Expert) presenting on the Telemetry system in Japan.



Photo 4. Training session by Mr. Mwandoe (JICA Experts Team) on Introduction to Mike Hydro Schematic for pilot study area & populating Mike Schematic.



Photo 1. Mr. Josiah Maina (WRA) presenting on introduction to Mike's workbench Graphical user interface.



Photo 5. Practical session with the participants.



Photo 2. Mr. Rueben Ngessa (WRA) presented on Field Equipment Installation; (SEBA and Data logger communication).



Photo 6. Dr. Masika (JICA Experts Team) led the questions and discussion sessions.

3. Key findings from the Training

- JICA Team confirmed that WRA installed Mike Info at Regional and Sub-regional offices.
- Participants appreciate the strength of Mike Suite software for supporting decisions in Water Resource Management.
- There is a need to enhance training in real-time equipment maintenance and operation as well as the application of Mike software.
- Telemetric stations transfer data directly to the WRA Head office.
- There are challenges in logistics for telemetric station operation and management, data quality control, use, and exchange in the Tana Basin.

4. Lessons

- Staff are willing to train and apply Mike Suite tools.
- Lack of adequate Mike Software licenses is impeding the Mike Info application.
- Limited technical coordination for real-time telemetric data activities limits the application of Mike tools.

5. Way Forward

WRA should enhance the following: -

- Involve regional and sub-regional technical staff in telemetric equipment installation, operation, and maintenance.
- Utilize the existing network to establish a framework for Water Allocation Planning (WAP) and Flood Early Warning.

- Mobilize resources for operationalizing Mike Suite facilities for Integrated Water Resource Management.
- Implement comprehensive training programs focused not only on Mike Suite software but also on the holistic management of telemetric stations, including real-time data analysis and emergency response protocols.
- Establish standardized protocols for data quality control across all regional and sub-regional offices to ensure consistent and accurate data is used in decision-making.
- Foster stronger collaboration between WRA and other stakeholders, such as NGOs and academic institutions, to leverage additional expertise and resources for telemetric station management.
- Develop and implement a long-term plan for the regular upgrading and maintenance of telemetric stations to minimize downtime and enhance data reliability.

6. Next Activity

From the end of August to September 2024, the final activity of the JICA Experts Team will be conducted. Two main seminars are scheduled to be held in Embu (September 17, 2024) and in Nairobi (September 19, 2024).



Kenya Water Resources Advisor JICA Experts Team

No.12(September 2024)

Newsletter No. 12

The tenth fieldwork was conducted in September 2024 by three Japanese Experts and four national staff. The newsletter highlights the project activities carried out during this period and the outcomes achieved.

1. Project Background

A study of "The National Water Master Plan 2030 (NWMP 2030)" was conducted by the Water Resources Management Authority (WRMA: former governmental agency now renamed WRA) as the executing agency with the assistance of Japan International Cooperation Agency (JICA) during the period from October 2010 to November 2013. The study supported the formulation of water resource development and management plans for all six basin areas in the country and action plans for strengthening water resource management capacity.

In 2017, aiming to strengthen water resource management based on appropriate monitoring, JICA implemented "JICA Expert for Water Resources Management" activities from January 2017 to September 2019. Various activities were implemented such as discharge measurement and installation of water level gauges, which contributed much to the capacity building of WRA staff in its headquarters, Embu Regional Office as well as five other Regional Offices. However, it is further required to level up the capacity of WRA staff so that they can achieve early implementation of plans formulated by NWMP 2030 and perform the tasks stipulated in the new Water Act 2016.

As a follow-up, the 'Kenya Water Resources Advisor Team' was constituted to strengthen water resources management skills for WRA staff in the Tana Basin area for the period April 2021 to April 2024. The activities period was further extended up to October 2024. Among the activities under implementation include discharge measurement, river cross-sectional survey, preparation of the H-Q curve, analysis of climate change effects, and operation and management of the database.

2. Activities

This newsletter highlights the seminars held in Embu and Nairobi in September 2024 which aimed at enhancing information sharing for Water Resources Monitoring and Analysis.

2.1 Seminar in Embu and Nairobi

In September 2024, the JICA Experts Team in collaboration with the Water Resource Authority organized two key seminars in Embu and Nairobi.

- In Embu, the event was held on 17th September 2024 at the Izaak Walton Inn Hotel, whereas in Nairobi, it was held on 19th September 2024 at the Fairview Hotel.
- These seminars aimed at improving information sharing and communication methods in Water Resource Management and fostering collaboration among key stakeholders in Kenya's Water Resource Management sector.
- Key stakeholders in the water sector, both at the regional and national levels, were in attendance. Participants included; representatives from the Ministry of Water, Sanitation and Irrigation, Kenya Meteorological Department, National Drought Management Authority, National Irrigation Authority, Kenya Space Agency, Hydrological Society of Kenya, Athi Water Works Development Agency, and more.

Program highlights (areas of presentation and discussion) included:

•Introduction of WRA's Work:

This session provided an overview of WRA's efforts in water resource assessment and monitoring, emphasizing its critical role in managing water resources within the Country.

•WRA and JICA Experts Team Joint Activities in the Tana Basin:

Participants were briefed on the collaborative work between WRA and the JICA Experts Team in the Tana Basin. These joint efforts have focused on improving real-time data acquisition, hydrological surveys, and capacity building in water resource management.

• Introduction of JICA Experts Team Activities:

The JICA Experts Team Leader briefed the participants on the overall activities carried out in Tana Basin since the project's commencement. Details of the project's goals, expected outputs, target areas of activities, the flow charts illustrating the planned and actual implementation schedule, and also the progress of activities for each output were duly presented.

• Hydrological Monitoring and Data Management:

JICA experts presented the project's activities and outputs aimed at strengthening WRA's hydrological monitoring and data management mandate in the Tana Basin. WRA's mandate in monitoring, regulation, and data management of hydrological data was discussed in general. It was highlighted that the Expert's Team performed onsite training and workshops on reading water levels, measuring discharges, conducting river cross-section surveys, and analyzing data, all to enhance the quality of data for water resources management and regulation that is reliable and effective.

•Real-Time Telemetric Data Acquisition and Applications:

The key highlights were; the status quo of the current situation of WRA's observation and data transmission facilities, output of activities by the JICA Experts Team, and future issues in telemetry in terms of new technologies for improvement of the Flood Early Warning System.

• Introduction of Flood Early Warning System and RRI:

An outline of the April 2024 floods caused by heavy rains was highlighted in this session.

Events that led to extreme flooding in the Tana Basin together with the damages caused were outlined. Future climate risk due to projected change in climate impact drivers in Eastern Africa was also looked into. Also, there was a significant discussion focused on the implementation of a Flood Early Warning System using the Rainfall Runoff Inundation (RRI) model. This system aims to enhance disaster preparedness by predicting floods and helping authorities take timely action.



Photo 1: Group Photo during the Seminar in Embu



Photo 2: Ongoing seminar session in Embu at Izaak Walton Inn Hotel



Photo 3.
Group photo
of Nairobi
seminar



Photo 4.
Seminar
session
ongoing at
Fairview
Hotel
Nairobi.

3. Seminar Feedback

After every presentation, there was an interactive question and answer session that sought to obtain feedback and clarifications. At the end of both seminars, questionnaires were issued to the participants to gather their insights.

Key expectations from the participants for collaboration with WRA were centered around: Climate Analysis, Catchment Conservation, and Protection Programs. These areas were flagged as critical services that participants' organizations expected from WRA.

Several Participant organizations suggested areas of improvement as follows:

- National Irrigation Authority; emphasized the need for hydrological data sharing from telemetric stations across all basins.
- Kenya Space Agency; suggested further collaboration on satellite image use for decision support and hazard maps.

- Others highlighted the need to replicate FEWS in other basins and develop a national real-time flood information system.

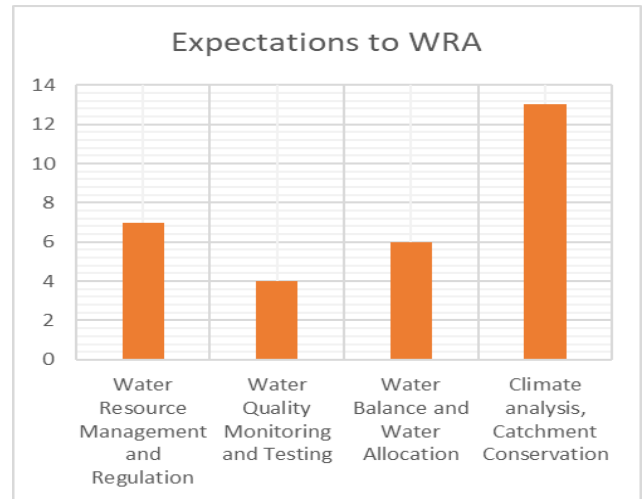


Figure 1: Participants' expectations of WRA (Source: Seminar questionnaires)

4. Way Forward

Combating Climate change through Catchment Conservation, and Protection Programs is one of the key areas identified from the seminars. There is an emerging challenge, especially related to flooding, a major natural disaster in Kenya that causes loss of life, property damage, displacement, and agricultural degradation, with El Nino events worsening flood severity and frequency.

Now is the time to plan and implement enhanced flood mitigation measures incorporating global best practices with local knowledge and conditions. JICA is collaborating with the Ministry of Water, Sanitation, and Irrigation in formulating a framework for future flood control interventions.

As of the end of September 2024, the JICA Experts Team completed its assignment in Kenya. We would like to express our sincere gratitude to the Water Resources Authority and related organizations in Kenya together with JICA for their kind support to the activities of the JICA Experts Team.

Appendix 2

Newspaper Articles related to Flood, Drought and Other Water Sectors

Newspaper Articles from April 2022 to July 2024 (Daily Nation)

No.	DATE (DD-MMM-YY)	HEADING	Related to							
			Flood	Drought	Food Security	El Nino	Dam construction	Water supply	Water permit	Climate Change
1	06-Apr-22	Thousands in Baringo's Asals stare at starvation		x						
2	30-Apr-22	Asal counties to cover locals against drought and floods	x	x						
3	05-May-22	County's Sh11 billion plan for response to natural disasters								x
4	06-May-22	Water Statistics - The Kenyan Situation								x
5	06-May-22	Water, land and hunger key issues for Tana River voters								x
6	04-Jul-22	Thousands face huger amid biting drought		x	x					
7	13-Jul-22	Interruption of water supply, Nairobi City Water & Sewerage Company Ltd. Thursday 14th July 2022 from 6.00 am to Mid Night the same day		x				x		
8	22-Jul-22	4.1m Kenyans in arid lands battle food shortage - IMF		x	x					x
9	29-Jul-22	Celebrating the Completion of Thiba Dam, Mwea Irrigation Development Project Another milestones in the history of our cooperation with Kenya								x
10	29-Jul-22	Celebrating the Completion of Thiba Dam, Mwea Irrigation Development Project A benefit of our collaboration with JICA								
11	31-Jul-22	Water crisis		x						
12	31-Jul-22	Why water matters in combating climate crisis River on the verge of drying up		x						x
13	31-Jul-22	Building and Fixing Dams for Water Security					x			
14	31-Jul-22	Here are our climate-resilient water programmes								x
15	31-Jul-22	Thwake Dam Initiates Successful Adaptation and Mitigation Measures on Climate Change					x			x
16	31-Jul-22	Climate change mitigation and adaptation in Lake Victoria North A dam of hope: How Thwake is set to propel millions of livelihoods					x			x
17	31-Jul-22	The battle against unclean water: A case for circular water economy Addressing climate change through skills development			x					x
18	31-Jul-22	Intensifying irrigation for food security and community resilience against climate change			x					x
19	31-Jul-22	Isotope Hydrology in climate action Climate change actin by Tana Water Works Development Agency						x		x
20	31-Jul-22	Climate change adaptation indicatives by Northern Water Works Development Agency								x
21	31-Jul-22	Drought piles pressure on freshwater sources		x						x
22	31-Jul-22	Activities to clock 200 marathons for water		x						
23	31-Jul-22	Regulatory environment for resilience in water services								x
24	22-Aug-22	Hunger stalking a million Kenyans as drought worsens, agency reveals		x						
25	23-Aug-22	Thiba dam reservoir fills up, raising rice farmer's hopes					x			x
26	29-Aug-22	Launch of Tana Water Works Development Agency Strategic Plan 2022-2027 TWWDA a Trailblazer in Water and Sanitation Provision in Mt Kenya						x		x
27	29-Aug-22	Launch of Tana Water Works Development Agency Strategic Plan 2022-2027 Why Agency's Board Wants All on Board								x
28	29-Aug-22	Launch of Tana Water Works Development Agency Strateg Our Agenda Going Forward					x	x		x
29	29-Aug-22	Thousands grapple with hunger as drought hits Marsabit County After elections, fucus for over 10 governors shifts to dry spel		x						

No.	DATE (DD-MMM-YY)	HEADING	Related to								
			Flood	Drought	Food Security	El Nino	Dam construction	Water supply	Water permit	Climate Change	Water in General
30	30-Aug-22	Deadly Search for Water Climate wars: How desperate search for water lures families to death		x							
31	03-Sep-22	Families agonise as drought bites		x							
32	03-Sep-22	Prepare for depressed rainfall, Met warns		x	x						
33	21-Sep-22	No respite - The short rains between October and December are also likely to be disappointing Famine crisis leaves 4 million in need of aid		x							
34	21-Sep-22	Crisis - Several parts of the country are in the throes of a biting drought Over 1m children in need of treatment for malnutrition		x							
35	25-Sep-22	Lives at stake as famine, hunger ravage villages		x	x					x	
36	26-Sep-22	Ruto: 3.1 million Kenyans starving		x	x						
37	04-Oct-22	More Kenyans hungry in 2022 compared to 2021		x	x						
38	14-Oct-22	Rice farmers stare at risk of losing 30,000ha of crop		x	x						
39	15-Oct-22	Over 4m people face starvation as drought persists in arid areas		x							
40	21-Oct-22	Villagers battle thirst as key water pan runs dry		x							
41	22-Oct-22	Children drop out school as hunger ravages arid counties		x	x						
42	01-Nov-22	Two years ago, I had 35 goats and sheep. Only five have survived while the rest of the herd perished from the drought		x							
43	27-Feb-23	Disaster looms as key rivers dry up across the country		x							
44	27-Feb-23	Time state declared the ravaging drought a national emergency		x							
45	03-Mar-23	Tighten your belts, warns weatherman as rains projected to fail			x						x
46	04-Mar-23	Reprieve - Showers experienced in various parts of the country bring hope after the drought Rains are here! Farmers get busy		x							
47	04-Mar-23	Embu launches plan to end water shortage		x							
48	13-Mar-23	Met: Long rain seasons to start soon thanks to Cyclone Freddy									x
49	13-Mar-23	Electricity - Hydropower production dropped by 64pc to 112.7m units in Feb Hydropower generation at record low on drought		x							
50	22-Mar-23	What the Government is doing to increase water supply coverage, and the outcomes so far						x			
51	22-Mar-23	We are on course to the 2030 water supply target						x			
52	22-Mar-23	How TWWDA is accelerating expansion of clean water and sanitation services						x			
53	22-Mar-23	Implementing multiple projects to solve water and sanitation challenges in the ASALs						x			x
54	22-Mar-23	Diving into sustainability: TARDA's innovative solutions for sustainable water management		x				x			x
55	22-Mar-23	A river of woes a trench locals hope is saving grace		x				x			x
56	09-May-23	PS flags off vehicles for the water police unit to protect infrastructure									x
57	15-May-23	Itare biggest beneficiary of sh 50bn new budget allocation for dams					x				
58	16-Jun-23	Locals reject raising of dam spillway, say it will limit flooding					x				x
59	30-Jun-23	City residents face higher water bills in new plan						x			x

No.	DATE (DD-MMM-YY)	HEADING	Related to								
			Flood	Drought	Food Security	El Nino	Dam construction	Water supply	Water permit	Climate Change	Water in General
60	02-Aug-23	Sh11.2bn lost annually to water theft, leaks						x			x
61	12-Aug-23	Japan donates two water trucks to arid counties		x							x
62	17-Aug-23	WRA Public notice (Water Permits)							x		
63	22-Aug-23	Proposed changes to law set to deny counties right to sell bulk water						x			
64	29-Aug-23	Water regulator designates critical water catchments in Kenya as protected areas									x
65	29-Aug-23	Thwake Dam completion date moved amid dispute					x				
66	31-Aug-23	State seeks Sh 33 billion to mitigate El Nino rains impact				x					
67	10-Sep-23	Brace for El Nino from next month, scientists give notice Scaling up nature-based, locally-led climate action to increase the resilience of farmers and forest communities to climate chage	x			x				x	
68	20-Sep-23	WRA Public notice (El Nino rains alert)	x			x					
69	26-Sep-23	Dam project puts Tharaka community shrine at risk					x				
70	26-Sep-23	Authority taps into the Internet of things (IoT) to implement smart water metering infrastructure network						x			x
71	08-Oct-23	The disappearance of Meru's mighty rivers									x
72	09-Oct-23	MWSI Public notice (Invitation for public participation)									x
73	10-Oct-23	Be proactive to protect minors from El Nino				x					
74	11-Oct-23	Fears El Nino will cut off towns				x					
75	11-Oct-23	Nairobi City Water & Sewerage Company Public notice (Water Supply interruptions in Nairobi City a its Environs)						x			x
76	23-Oct-23	El Nino forecast change calls for Met's accuracy				x					
77	24-Oct-24	WRA calls on dam owners to enhance safety measures ahead of El Nino rains	x			x	x				
78	06-Nov-23	Weatherman: Rains to persist till January	x			x					
79	07-Nov-23	Ignore El Nino warning at your peril: weatherman				x					
80	09-Nov-23	Thousands homeless as rains wreak havoc	x								
81	14-Nov-23	Pregnant woman swims across flooded river to deliver her son	x								
82	21-Nov-23	Death a destruction as floods maroon homes	x								
83	21-Nov-23	Declare floods national disaster to tackle crisis	x								
84	23-Nov-23	Governors clash with DP on El Nino response funds Declare the heavy rains national disaster, says MPs UN puts flood deaths at 60 as 27,000 households displaced	x			x					
85	25-Nov-23	Several dead, roads closed as floods cause more havoc	x								
86	28-Nov-23	Sakaja: Sh 15bn funding to boost city's water supply						x			x
87	29-Nov-23	120 killed as 89,000 families displaced by ongoing floods	x								
88	04-Dec-23	MP: Shortcut, lack of fuel got us stranded in flooded River Tana	x								
89	06-Dec-23	El Nino toll jumps to 160 as more displaced families moves to camps				x					

No.	DATE (DD-MMM-YY)	HEADING	Related to								
			Flood	Drought	Food Security	El Nino	Dam construction	Water supply	Water permit	Climate Change	Water in General
90	13-Dec-23	Tana River leaders seek long-tern solutions for floods	x								
91	14-Dec-23	Nairobi City Water & Sewerage Company Public notice (Water Supply interruption in some parts of Nairobi City County)						x			x
92	17-Dec-23	Expect more downpours, Kenyans told	x								
93	20-Dec-23	WRA Public notice (Water Permits)							x		
94	21-Dec-23	Where is the food? Patience runs out for flood victims	x								
95	08-Jan-24	Tana River flood victims in limbo over county order	x								
96	10-Jan-24	After floods Tana River residents now suffer from heat	x								
97	19-Jan-24	El Nino's trail of misery: Women, children take the brunt of flood waters	x			x					x
98	20-Feb-24	20,000 families added to flood insurance scheme					x				
99	22-Feb-24	Water firms agree to end dispute over running of Sh 1bn dam						x			
100	05-Mar-24	KenGen mulls using waste water to produce power									x
101	13-Mar-24	Completion of Itare Dam will take 'at least 4 more years'					x				
102	22-Mar-24	Calls for tighter teamwork if Kenya is to achieve set water targets									x
103	22-Mar-24	UN on the growing demand for water and why this shouldn't be allowed to get out of hand									x
104	22-Mar-24	No more water conflicts: How projects by Tana River County Government are bringing relief to residents									x
105	22-Mar-24	Water meters you can communicate with: smart metering solutions penetrate the local market						x			x
106	26-Mar-24	7 dead as floods cause havoc in Nairobi	x								
107	07-Apr-24	Water firms leak over 10bn in revenue in the year to June 2022						x			
108	14-Apr-24	Met warns of heavy rain in 6 day forecast	x								
109	16-Apr-24	Heavy rains leave a trail of death, ruin property across the country	x								
110	18-Apr-24	Kindiki issues red alert over floods	x								
111	22-Apr-24	Wrath of mother nature: Death, ruin script plays on	x								
112	23-Apr-24	Landslides, flooding warnings issued	x								
113	23-Apr-24	Under water: Kenyans in agony amid heavy floods	x								
114	24-Apr-24	It's raining everywhere, no place to hide, Kenyans told to brace for tougher times	x								
115	25-Apr-24	Floods nightmare	x								
116	25-Apr-24	Rains batter Nairobi and its environs, leave residents counting heavy losses	x								
117	25-Apr-24	Death and destruction as floods ravage the country	x								
118	27-Apr-24	Over 70 killed, thousands displaced in floods havoc	x								
119	29-Apr-24	Death toll climbs to over 80 amid forecast of more rain	x								
120	29-Apr-24	Kenya Airways diverts flights due to heavy rains, poor visibility Schools in flood-hit areas to remain shut: Machogu	x								

			Related to								
No.	DATE (DD-MMM-YY)	HEADING	Flood	Drought	Food Security	El Nino	Dam construction	Water supply	Water permit	Climate Change	Water in General
121	30-Apr-24	Black Monday	x								
122	30-Apr-24	Death, destruction haunt Mai Mahiu villages after floods	x								
123	30-Apr-24	Turkana cut off as rains cause devastation across country	x								
124	01-May-24	Cloud of grief shrouds Mai Mahiu as floods claim 48 lives	x								
125	01-May-24	Expect warm temperature, heavy rain: weather man	x								
126	01-May-24	Ruto: Residents in at-risk places have 2 days to move out	x								
127	01-May-24	Leaders offer aid as flood victims count losses	x								
128	02-May-24	Marooned: Roads closed and homes under water	x								
129	02-May-24	Death toll rises, more roads closed due to flooding	x								
130	02-May-24	Farmers stare at losses as acres of crop destroyed	x								
131	02-May-24	Search on for the missing in Mai Mahiu but hope is waning	x								
132	03-May-24	Coastal region likely to be hit by tropical storm	x								
133	03-May-24	Prepare for heavy rain as cyclone Hidaya lands, Coast residents told	x								
134	03-May-24	Flood wreck lodges, kill animals in Maasai Mara	x								
135	04-May-24	A nation in crisis	x								
136	04-May-24	National treasury to splash 20 billion in response to ongoing floods Why schools can't reopen, just yet, for Term Two calendar	x								
137	04-May-24	Ruto's tough measures in bid to contain floods	x								
138	04-May-24	Pain of life in IDP camps as 115 set up, floods death toll hits 210	x								
139	05-May-24	Why Kenya is on red alert over cyclone	x								
140	05-May-24	Kenya on high alert after Tanzania hit by cyclone	x								
141	05-May-24	Volunteers to the rescue as floods ravage Kenya Tally of people killed now rises to 219, more rainfall expected	x								
142	06-May-24	State seeks nod to spend Sh 10bn on floods crisis interventions to minimise loss of lives	x								
143	06-May-24	Scores displaced as River Nyando burst its banks	x								
144	06-May-24	One dead, 22 hurt as cyclone Hidaya hits	x								
145	07-May-24	State to spend Sh1bn to rehabilitate damaged schools	x								
146	07-May-24	Hard reality of rebuilding lives start to set in for Mai Mahiu flood victims	x								
147	08-May-24	Floods plague Cholera outbreak as State confirms 34 cases	x								
148	08-May-24	Fissure literally splits village in Nakuru	x								
149	08-May-24	Alarm raised as state confirms 34 Cholera cases	x								
150	08-May-24	Kindiki orders Kijabe families to be evicted	x								
151	09-May-24	Schools to reopen on Monday even as safety fears persist	x								

No.	DATE (DD-MMM-YY)	HEADING	Related to								
			Flood	Drought	Food Security	El Nino	Dam construction	Water supply	Water permit	Climate Change	Water in General
152	09-May-24	Flooding crisis: Grandmother recounts night of terror in Nairobi	x								
153	09-May-24	Trending Photo of the week	x								
154	14-May-24	It is chaos in ill-prepared schools as second term starts after deadly floods	x								
155	14-May-24	Hunger looms in Rift Valley as floods leave behind a harvest of woes	x								
156	15-May-24	Floods kill 12 in 24hours as death toll now hits 289	x								
157	16-May-24	Floods serious threat to our food security	x		x						
158	19-May-24	Why Nairobi is flooding	x								
159	19-May-24	Nairobi's devastating floods expose decades of poor urban planning	x								
160	19-May-24	Kibera's forgotten residents battle flood amid looming evictions	x								
161	20-May-24	Floods expose gaps in disaster preparedness	x								
162	22-May-24	Met: Expect heavy rains, rough seas	x								
163	23-May-24	Two dead at the Coast as Cyclone Ialy causes havoc	x								
164	03-Jul-24	Floods: Farmers count big losses	x								
165	30-Jul-24	Long wait for flood victims as ethnic rows mar resettlement plan	x								
		Total	78	32	12	12	12	20	2	12	33

Appendix-3

Information on Flood and Drought Damages and their Countermeasures

Major Flood Articles Online (from December 2015 to May 2024)

NO.	DATE	TITLE	AREA	DAMAGE	LINK
F1	18-Dec-15	Kenya Red Cross dispatches relief food to Tana River flood victims	Handaraku	2440 households and 15,000 people affected	https://www.kbc.co.ke/kenya-red-cross-dispatches-relief-food-to-tana-river-flood-victims/
F2	10-Apr-17	Farmers In Garissa Counting Losses After River Tana Burst Its Banks	Sankuri, Balich	Crops swept away , 14 families marooned by flood water	https://www.citizen.digital/news/farmers-in-garissa-counting-losses-after-river-tana-burst-its-banks-163211
F3	10-Apr-18	Death toll from Tana River floods rises to 6 after body of woman is found	Bakuyu, Bura Town, Madogo, Mororo	Loss of lives, 400 families displaced	https://barakafm.org/2018/04/10/death-toll-from-tana-river-floods-rises-to-6-after-body-of-woman-is-found/
F4	12-Apr-18	Five killed in Tana River Flooding	Bilbil	Loss of lives- 2 small boys	https://infonile.org/en/2018/04/five-killed-in-tana-river-flooding/
F5	03-May-18	Schools fail to reopen as rains persist	Secondary schools:Kipini, Daku, Waldena, Galole Model, Nanighi. Primary schools: Bangale, Huruma, Furaha, Mapenzi, Hurara, Chewani, Hola, Rafiki, Mbalambala, Mulanjo, Ziwani, Mororo, Hatata. Other schools: Kalalani, Kanelati, Titila, Dada, Makadala, Wayuboru, Wayuduka, Kottita, Haroresa, Galili, Idhowe, Gamba, Odole, Kilelengawani, Ozi, Hewani, Wema	Schools shut down/partially closed; classrooms marooned and others destroyed, pit latrines sink	https://www.standardmedia.co.ke/amp/health-science/article/2001279028/schools-fail-to-reopen-as-rains-persist
F6	08-May-18	Tana River Residents In Distress	Gamba(Bandi &Gatheri villages)	32 villages sunk by flood water, 30,000 homesteads destroyed, 64,000 people displaced	https://www.citizen.digital/news/tana-river-in-distress-as-homes-submerged-in-floods-199417
F7	18-May-18	KenGen: We are not to blame for Garissa, Tana River floods	Garissa, Tana River	IDPs, flooded homes and destruction of properties	https://www.businessdailyafrica.com/bd/news/kengen-we-are-not-to-blame-for-garissa-tana-river-floods-2203704
F8	18-May-18	Red Cross situation report on 'KenGen floods'	Garissa, Tana River, Kitui Counties	97 people injured, 186 lost their lives(exclusive of deaths related to disease outbreaks), infrastructure damaged and crucial services such as transportation and health paralysed, 68780 acres of farmland submerged in water and crops destroyed.	https://reliefweb.int/report/kenya/kenya-floods-mdrke043-operations-update-no-1
F9	19-Nov-19	Over 3,000 People In Garsen Are Marooned Following The Bursting Of River Handarakulagha	Konemasa,Katsangi,Handaraku,Semi-karo (S.L)	Road network cut-off, over 3,000 people marooned,national exams disrupted	https://www.kenyanews.go.ke/over-3000-people-in-garsen-are-marooned-following-the-bursting-of-river-handarakulagha/
F10	24-Dec-19	Locals in distress as floods submerge villages in the Tana delta	Mwanja, Odhole, Samicha, Handaraku,Sogan	Submerged homes, severall families displaced	https://www.the-star.co.ke/counties/coast/2019-12-24-locals-in-distress-as-floods-submerge-villages-in-the-tana-delta/
F11	27-Apr-20	Floods Wreak Havoc In Ijara And Tana River	Tana River- Mikinduni, Kilindini : Ijara Garissa - Mansabubu, Gababa, Masalani,Boji	Crops swept away, transport network cut off, several families affected	https://www.kenyanews.go.ke/floods-wreak-havoc-in-ijara-and-tana-river/
F12	28-Apr-20	Floods paralyze transport in Tanariver leaving hundreds stranded	Dukanotu	Roads completely cut off, over 500 households affected	https://barakafm.org/2020/04/28/floods-paralyze-transport-in-tanariver-leaving-hundreds-stranded/
F13	10-May-20	Heavy rains destroy homes, cause landslides in Murang'a	Kagarii -Gatanga; Mariira-Kiharu; Maporomoko-near Thika; Mioro; Murarandia-Kahuru	Several families displaced and homes destroyed	https://www.the-star.co.ke/counties/central/2020-05-10-heavy-rains-destroy-homes-cause-landslides-in-muranga/
F14	15-May-20	3,000 residents stranded in Tana Delta floods	Mwanja, Odhole, Samicha, Handaraku,kikomo villages	7000 people displaced, 3000 others stranded in flooded villages	https://www.the-star.co.ke/news/2020-05-16-3000-residents-stranded-in-tana-delta-floods/
F15	06-Apr-21	Tana River Residents Decry The State Of Impassable Road	Bilbil	Lack of basic commodities due to broken road network	https://www.kenyanews.go.ke/tana-river-residents-decry-the-state-of-impassable-road/
F16	04-Nov-23	Beware! KeNHA warns motorists of second landslide on Meru- Mikinduri-Maua road	Meru- Mikinduri- Maua	Road impassable due to landslide	https://www.the-star.co.ke/news/2023-11-04-beware-kenha-warns-motorists-of-second-landslide-on-meru-mikinduri-maua-road/
F17	05-Nov-23	Garissa Town Reels From Floods After Tana River Breaks Its Banks	Tana River, Garissa	Roads and bridges swept away, 70 lives lost and 36000 households displaced	https://www.citizen.digital/news/garissa-town-reels-from-floods-after-tana-river-breaks-its-banks-n332020
F18	05-Nov-23	Floods reign supreme after Tana River burst its banks	Madogo- Tana River, Hola-Garissa	Road network cut off and transport paralyzed	https://www.the-star.co.ke/news/2023-11-25-floods-reign-supreme-after-tana-river-bursts-its-banks/

Major Flood Articles Online (from December 2015 to May 2024)

NO.	DATE	TITLE	AREA	DAMAGE	LINK
F19	08-Nov-23	Red Cross: Water in Tana River has risen to critical level	Garissa, Tana River	More than 200 families displaced, fifty households, churches and schools flooded	https://www.the-star.co.ke/news/2023-11-08-red-cross-water-in-tana-river-has-risen-to-critical-level/
F20	08-Nov-23	Tana River flood victims face food and clean water shortage	Kone, watta Omara-Tana River	Shortage of food and clean water, more than 2000 families displaced, two boys dead, 300 cattle swept away,schools flooded	https://nation.africa/kenya/counties/tana-river/tana-river-flood-victims-face-shortage-of-food-clean-water-4427334
F21	09-Nov-23	14 dead, over 30,000 displaced as floods wreak havoc in North Eastern	Garissa, wajir, Mandera	Bridge washed away, major roads cut off, 14 people lost lives due to drowning	https://nation.africa/kenya/counties/garissa/14-dead-over-30-000-displaced-as-floods-wreak-havoc-in-north-eastern-4428256
F22	09-Nov-23	Two people die from drowning as River Tana Burst its banks	sala ward- Madogo division Tana River County	2 peope dead, famiel displaced	https://www.kenyanews.go.ke/two-people-die-from-drowning-as-river-tana-bursts-its-bunks/
F23	09-Nov-23	15 children rescued as floods wreak havoc in Tana River County	Feji(Garsen) - Tana River county	15 children stuck in farms	https://www.kbc.co.ke/15-children-rescued-as-floods-wreak-havoc-in-tana-river-county/
F24	09-Nov-23	Residents near Tana River Dams urged to relocate as flood risks rises	Seven Folks dams	So far 100,000 households displaced	https://www.capitalfm.co.ke/news/2023/12/residents-near-tana-river-dams-urged-to-relocated-as-floods-risk-rises/
F25	24-Nov-23	From drought to deluge: Kenyan villagers reel from floods	Garissa, Tana River	Loss of lives, families displaced,loss of property, food insecurity	https://www.monitor.co.ug/uganda/news/from-drought-to-deluge-kenyan-villagers-reel-from-floods-4443712
F26	04-Apr-24	Mwea Residents Left Homeless After River Thiba Broke Its Banks	Mwea- Kirinyaga County	Houses destroyed and swept away, hectares of crops washed away	https://www.kenyans.co.ke/news/99387-mwea-residents-left-homeless-after-river-thiba-broke-its-banks
F27	08-Apr-24	KeNHA closes Nairobi-Garissa Road due to flooding at Mororo	Mororo- Tana River	Road impassable due to flooding	https://www.the-star.co.ke/news/2024-04-08-kenha-closes-nairobi-garissa-road-due-to-flooding-at-mororo/
F28	09-Apr-24	Hundreds stranded as floods wreak havoc along Garissa-Mwingi road	Tula and Arer area Bangale sub-county in Tana River	Road network cut off and transport paralyzed due to flooding	https://www.the-star.co.ke/counties/north-eastern/2024-04-09-hundreds-stranded-as-floods-wreak-havoc-along-garissa-mwingi-road/
F29	09-Apr-24	51 passengers narrowly escape death as bus is swept by floods	Lager Areli- Garissa County	Death related risks	https://nation.africa/kenya/counties/garissa/51-passengers-narrowly-escape-death-as-bus-is-swept-by-floods-4584132
F30	11-Apr-24	Kenya: Heavy Rains and Flooding Update - Flash Update (11 April 2024)	Marsabit, Turkana, Tana River, Garissa, Kirinyaga, Muranga, Kiambu, Meru, Kisumu, Nairobi and Kitui counties.	3000 households displaced, 339 livestock killed, unknown acres of croplands lost	https://reliefweb.int/report/kenya/kenya-heavy-rains-and-flooding-update-flash-update-1-11-april-2024
F31	12-Apr-24	Red Cross: At least 323 households affected by heavy rains in Kirinyaga	Thiba in Mwea West Kirinyaga County	323 households displaced	https://www.the-star.co.ke/news/2024-04-12-red-cross-at-least-323-households-affected-by-heavy-rains-in-kirinyaga/
F32	15-Apr-24	Two killed as floods wreak havoc in Tana River	Tana North	Loss of lives, families displaced	https://www.the-star.co.ke/counties/coast/2024-04-15-two-killed-as-floods-wreak-havoc-in-tana-river/
F33	16-Apr-24	Over 100 Families Flee Homes As Floods Rock Kirinyaga	Ngurubani in Mwea Kirinyaga County	Over 100 families displaced	https://www.citizen.digital/news/over-100-families-flee-homes-as-floods-rock-kirinyaga-n340442
F34	27-Apr-24	Garissa faces supplies shortage as floods cut off roads network	Garissa-Madogo Highway	Supply shortage of basic commodities	https://www.the-star.co.ke/news/realtime/2024-04-27-garissa-faces-supplies-shortage-as-floods-cut-off-roads-network/
F35	28-Apr-24	23 People Missing As Boat Capsizes In Tana River	Madogo - Tana River	23 people missing,	https://www.citizen.digital/news/23-people-missing-as-boat-capsizes-in-tana-river-n341214
F36	29-Apr-24	Hundreds displaced in Garissa and Mororo, Tana River as floods wreak havoc	Garissa and Tana River Counties	Houses sub-merged &Families displaced, road network destroyed, property destroyed	https://www.the-star.co.ke/news/realtime/2024-04-29-hundreds-displaced-in-garissa-and-mororo-tana-river-as-floods-wreak-havoc/
F37	29-Apr-24	Floods Continue To Wreak Havoc In Garissa	Bulla punda, Kamor, Sheikh, vumbi, Windsor, Bulla nyuki - in Garissa County	Houses submerged and families displaced	https://www.kenyanews.go.ke/floods-continue-to-wreak-havoc-in-garissa/
F38	13-May-24	Its swimming and canoe rides for Tana River children as schools open	Watta Hamesa village- Tana River County	Road network destroyed by floods	https://nation.africa/kenya/counties/tana-river/canoe-rides-for-tana-river-children-as-schools-open--4621648
F39	13-May-24	Section of Gamba-Tana River road swept away by floods	Tana River County	Police station swept away, road network destroyed	https://www.the-star.co.ke/news/realtime/2024-05-13-section-of-gamba-tana-river-road-swept-away-by-floods/
F40	14-May-24	Kirinyaga: Learners face trouble Resuming School After Kiwe Bridge Collapse	Mwea Kirinyaga County	Bridge swept away at Kiwe River due to floods	https://www.citizen.digital/news/kirinyaga-learners-face-trouble-resuming-school-after-kiwe-bridge-collapse-n342103
F41	14-May-24	Floods update: Fatalities rise to 289 after 12 more deaths	Country wide	57120 households displaced, 1967 schools affected, 289 fatalities, 75 people missing, 188 sustained injuries & 62 health facilities across 11 counties damaged	https://www.the-star.co.ke/news/2024-05-14-floods-update-fatalities-rise-to-289-after-12-more-deaths/

Major Drought Articles Online (from March 2017 to September 2023)

NO.	DATE	TITLE	AREA	DAMAGE	LINK
D1	14-Mar-17	Garissa fights disease, hunger, in long drought	Fafi, Balambala	Famine leading to starvation and malnutrition, lack of pasture deteriorating livestock health	https://www.hiiraan.com/news4/2017/Mar/141031/garissa_fights_disease_hunger_in_long_drought.aspx
D2	28-Feb-21	Garissa faces severe water crisis as drought worsens	Bahuri-Dadaab; Abdisamat, Shimbirey, Shentabacaad-Balambala; Lagdera, Ijara, Hulgho	water pans dried up and boreholes broken down	https://www.the-star.co.ke/counties/north-eastern/2021-02-28-garissa-faces-severe-water-crisis-as-drought-worsens/
D3	18-Jun-21	Water shortage hits Tana River, locals pray for rainfall	Garsen town and its environs	Households use so much money to get little water, Water from TIS causes infections among children	https://www.standardmedia.co.ke/counties/article/2001415994/water-shortage-hits-tana-river-locals-pray-for-rainfall
D4	06-Sep-21	Over 60,000 people facing starvation in Tana River county	Tana North- Lakole, Hosingo, Titila Tana River- Gururi, Goticha, Wayu-Duka, Haroresa	Severe food and water shortage; 63,000 people hunger stricken and water sources have dried up	https://www.standardmedia.co.ke/coast/article/2001422756/over-60000-people-facing-starvation-in-tana-river-county
D5	07-Sep-21	The agony of Assa village in Tana River County as drought bites	Assa-Garsen	Hunger & starvation, disruption of normal routine in search of water such as schooling	https://thecounty.co.ke/the-agony-of-assa-village-in-tana-river-county-as-drought-bites/
D6	01-Oct-21	Meru farmers, Isiolo herders unite to survive drought	Lachathuriu-Tigania west; Tigania East, Maraa-South Imenti; Kamweline, Ithata, Ngitana, Mura ra, Kachiuru, Nginyo-Igembe North	More than 120,000 people in need of food	https://www.breakingkenyanews.com/2021/10/meru-farmers-isiolo-herders-unite-to.html
D7	07-Oct-21	Tana River County Drills Boreholes Across County As Part Of Drought Response Initiative	Ngao, Gururi, Waldena, Lakole	Residents walking hundreds of kms in search of water, many households affected by famine	https://shahidinews.co.ke/2021/10/07/tana-river-county-drills-boreholes-across-county-as-part-of-drought-response-initiative/
D8	08-Mar-22	Drought Hits Tana River, Residents Seek Food Aid	Tana River County	68,000 people affected due to famine, declined crop and livestock production	https://www.kenyanews.go.ke/drought-hits-tana-river-residents-seek-food-aid/
D9	13-Jun-22	Children Hit Hard By Drought	23 Arid and semi-arid countries	malnutrition in children due to famine, livestock death, poor health conditions of livestock due to little pasture regeneration	https://www.kenyanews.go.ke/1million-children-malnourished-in-drought-affected-regions/
D10	04-Jul-22	'The conflict takes two forms': How worsening droughts are fuelling tensions in Kenya	Tana River County- Matanya village, Subo village, Ruko village	Dried water pans, livestock death, conflicts, long search of water and pasture	https://www.thejournal.ie/conflict-over-drought-in-kenya-5805313-Jul2022/
D11	04-Jul-22	Red Cross to buy off livestock hit by drought in 14 counties	Tana River County- Tana North, Tana Delta and Tana River sub- counties	Dried water pans, famine, livestock death	https://www.the-star.co.ke/counties/coast/2022-07-04-red-cross-to-buy-off-livestock-hit-by-drought-in-14-counties/
D12	19-Sep-22	Drought worsens in hungry. Thirsty Garissa County	Garissa county- Lagdera, Daadab	Livestock death, close to 378,000 people facing starvation, malnutrition, source of livelihood destroyed	https://www.the-star.co.ke/counties/north-eastern/2022-09-19-drought-worsens-in-hungry-thirsty-garissa-county/
D13	28-Sep-22	Drought hits Tana River, 92,000 people face starvation	Assa, Osiango, Bisadi, Chifiri, Sabukia, Hakoka, Wayu boru and Wayu Duka, Odhoganda	Water shortage, lack of pasture	https://www.kenyanews.go.ke/drought-hits-tana-river-92000-people-face-starvation/
D14	11-Oct-22	Meru wetland put under key and lock as drought ravages region	Meru - Maua	environmental degradation due to human activities	https://nation.africa/kenya/counties/meru/meru-wetland-put-under-lock-and-key-as-drought-ravages-region-3980916
D15	28-Oct-22	Tana scales up water supply amid biting drought	Tana River	water scarcity	https://www.kenyanews.go.ke/tana-scales-up-water-supply-amid-biting-drought/
D16	15-Nov-22	Delay of short rains worsens drought situation	ASAL Counties	water scarcity, food shortage, lack of pasture	https://www.kenyanews.go.ke/delay-of-short-rains-worsens-drought-situation/
D17	01-Feb-23	Give us water, not fertilizer; Mt. Kenya farmers say as region suffers food crisis	Embu, Meru, Kirinyaga counties	Lack of food and water (close to 500,000 people starving), failed season crops, livestock death, malnutrition, Human-wildlife conflict	https://nation.africa/kenya/counties/give-us-water-not-fertiliser-mt-kenya-farmers-say-as-region-suffers-food-crisis-4106958
D18	08-Sep-23	Tana children struggle to survive as drought persist	Tana River - Wayu, Bura, Galole	Lack of food and water resulting to malnutrition, lack of pasture for livestock	https://nation.africa/kenya/counties/tana-river/tana-children-struggle-to-survive-as-drought-persists-3941388

Major Flood Articles in YouTube (From November 2023 to May 2024)

NO.	REGISTERED DATE	DAMAGE	AREA	LINK
1	12-Nov-23	Farms submerged and crops washed away	Tana River, Garissa, Mandera	https://www.youtube.com/watch?v=DKAY2ZNFq2M
2	08-Nov-23	Villages marroned, families displaced, road network destroyed	Tana Delta	https://www.youtube.com/watch?v=Y4Vky8QifjQ
3	10-Nov-23	Death and destruction	Garissa	https://www.youtube.com/watch?v=Zk2smZE7Yoo
4	06-Nov-23	Farmlands submerged	Garissa	https://www.youtube.com/watch?v=n7IvN-mUpp4
5	09-Nov-23	Humanitarian crisis(families displaced, properties destroyed, lack of food and clean water	Garissa	https://www.youtube.com/watch?v=_DicY46RAJA
6	09-Nov-23	Flooding	Kirinyaga	https://www.youtube.com/shorts/AgfvTTsooFo
7	06-Nov-23	Families displaced, livestock swept away,	Tana Delta	https://www.youtube.com/watch?v=j6hCUEO-2ik
8	26-Nov-23	Road network destroyed,families marooned, properties destroyed,	Madogo Tana River, Garissa	https://www.youtube.com/watch?v=NOmU0NG3kVk
9	23-Nov-23	Nairobi-Garissa road cut off by floods	road cut off at mororo-madogo area	https://www.youtube.com/watch?v=e2oWm-X80mM
10	28-Nov-23	Floods Cut Off North Eastern, Kenya From The Rest Of The Country	North Eastern	https://www.youtube.com/watch?v=bTQ0Schg1JI
11	27-Nov-23	Floods: food and fuel crisis	Tana river, Garissa,	https://www.youtube.com/watch?v=pq1S1GF5B8s
12	22-Nov-23	Families displaced	Tana Delta	https://www.youtube.com/watch?v=WtUvpVvXUBg
13	03-Dec-23	Loss of life, entire village submerged	Wema village -Tana River	https://www.youtube.com/watch?v=58KgrV3MGlc
14	04-Nov-23	More than 6,000 people displaced by floods	Igembe, Tigania, Maua regions in Meru	https://www.kenyamoja.com/video/more-6000-people-displaced-floods-meru-ktn-news-638956
15	03-Nov-23	More than 100 people displaced	Tigania west- Meru	https://www.kenyamoja.com/video/100-families-rendered-homeless-meru-heavy-rains-weather-man-warns-replica-floods-i-kbc-video
16	04-Apr-24	Over 700 families in Kirinyaga facing losses as they grapple with the aftermath of severe flooding	Mwea -Kirinyaga County	https://www.kenyamoja.com/video/over-700-families-kirinyaga-facing-losses-they-grapple-aftermath-severe-flooding-k24-video
17	24-Apr-24	Floods: 10 killed in Nairobi	Nairobi	https://www.youtube.com/watch?v=j9mOEgIYLC0
18	24-Apr-24	Athi River breaks its banks	Machakos county	https://www.youtube.com/watch?v=1SvoJd8MeKo&t=16s
19	24-Apr-24	Floods aerial view	24 Counties affected by floods	https://www.youtube.com/watch?v=r1bl_g_oUX4
20	27-Apr-24	Floods kill 83 people across the country	Several counties across the country	https://www.youtube.com/watch?v=67NDSVqITSo

Appendix 4

Status of Regular Gauging Stations in Tana Basin Area (As of June 15, 2022)

Status of Regular Gauging Stations in Tana Basin Area

No.	SRO in charge	Telemeterized:T	Data Logger:DL	Station ID	Station Name	Type of station	Lat.	Long	Status	Gauge Reader	Remarks	Site Visit	Key for Telemetering Stn.	Q mes. & Survey	Vandalized
1	Kerugoya			4DA14	Kamweti	IMU	-0.45354	37.36209	Operational	Yes	Under a bridge.				
2	Kerugoya	T		4DA11	Thiba	Special	-0.53839	37.36209	Operational	Yes	Located at downstream of Thiba Dam. Telemeterized in 2020 by KWSCR. With SEBA Data Logger functional.	26 Oct. 2021 by Okamura, Azuma	SRO		
3	Kerugoya	T		4DA13	Kiringa	Others	-0.53861	37.33474	Operational	Yes	Telemeterized by KMD but not yet handed over.				
4	Kerugoya			4DA12	Rutui	Special	-0.55176	37.32222	Operational	Yes	A lot of illegal water abstraction by farmers, especially those who are growing horticulture products.				
5	Kerugoya	T		4DA10	Thiba	IMU	-0.605611	37.3184	Operational	Yes	Located at downstream of Thiba Dam. Telemeterized in 2021 by KWSCR. Just upstream of NIA abstraction point.		HQ		
6	Kerugoya			4DA5	Murubara	Others	-0.61305	37.35233	Operational	Yes					
7	Kerugoya	T		4DB5	Nyamindi	IMU	-0.60271	37.36924	Operational	Yes	Located at upstream of NIA abstraction point. Telemeterized by KMD in March 2022. 1st staff gauge washed away and needs reinstallation.				
8	Kerugoya	T		4DA6	Murubara	Others	-0.71859	37.31219	Operational	Yes	Telemeterized by KMD in March 2022. 1st staff gauge washed away in July 2020 and needs reinstallation.				
9	Kerugoya	T		4BC5	Rwamuthambi	IMU	-0.51364	37.31219	Operational	Yes	Telemeterized by KMD in March 2022.				
10	Kerugoya			4DD2	Thiba	MU	-0.73409	37.51067	Operational	Yes	The first staff gauge stolen. ISODAQ Data Logger NOT functional. Due to Sensor ? Cable ? Main Body? Needs to be rectified.	27 Oct. 2021 by Okamura, Azuma			V
11	Kerugoya			4DC3	Rupingazi	IMU	-0.54276	37.44894	Operational	Yes				O	
12	Kerugoya			4DC6II	Kapingazi	Special	-0.49248	37.45863	Operational	Yes					
13	Kerugoya	T		4ECnew	Ena	IMU	-0.49901	37.72659	Operational	Yes	Telemeterized by KMD in March 2022.				
14	Muranga			4BE10	Tana Rukanga	MU	-0.72173	37.25212	Operational	Yes	JICA installed Data Logger in 2018, but before June 2021, it was vandalized with the door completely destroyed. Also flooded up to top.	26 Oct. 2021 by Okamura, Azuma			V
15	Muranga	T		4BC02	Tana Sagana	MU	-0.672	37.207	Not Operational	No gauge reader	1st staff gauge vandalized and not reinsalled yet. KWSCR telemeterized in 2021.				V
16	Muranga	T		4BE01	Maragua	MU	-0.74723	37.15685	Operational	Yes	Telemeterized by KWSCR in 2021. 2nd staff vandalized.	10 Jun. 2022 by Okamura, Azuma	HQ		V
17	Muranga	T		4CC8	Thika	MU	-1.09298	37.34966	Operational	Yes	Telemeterized by WRA (Capital Project) with SEBA Data Logger functional.	27 Oct. 2021 by Okamura, Azuma	SRO		
18	Muranga	T		4CC07	Thika	MU	-1.09241	37.36138	Operational	Yes	Telemeterized by KMD.				
19	Muranga		DL	4AD06	Gikira	Special	-0.56	36.91	Operational	Yes	Nairobi Water Supply Project installed HOBO Data Logger.				
20	Muranga		DL	4AD01	Gura	IMU	-0.52242	37.01636	Operational	by NBO water supply	Nairobi Water Supply Project installed HOBO Data Logger. Vandalized in 2021. Data read and given from NBO Water Supply.				
21	Muranga	T		4AC03	Sagana	IMU	-0.44712	37.028226	Operational	Yes	Telemeterized in 2019. Vandalized in 2020. KMD telemeterized in March 2022.			O	
22	Muranga	T		4CB04	Thika	IMU	-1.021	37.066	Operational	Yes	Telemeterized by KMD.	10 Jun. 2022 by Okamura, Azuma			
23	Muranga			4AC04	Chania	IMU	-0.421	36.958	Not Operational	No gauge reader	2nd staff gauge vandalized in 2019 and the 1st staff gauge vandalized in 2021. Need reinstallation with concrete post.	07 July 2021 by Okamura, Kato			V
24	Muranga	T		4BB01	Ragati	IMU	-0.66454	37.24068	Operational	Yes	Telemeterized in by KWSCR in 2019 with SEBA Data Logger functional.	26 Oct. 2021 by Okamura, Azuma	SRO		
25	Muranga			4CA02	Chania	IMU	-1.02424	37.06487	Operational	Yes	Telemeterized in by KWSCR in 2019, but vandalized in 2021. 1st staff gauge needs total rehabilitation.		SRO		

Status of Regular Gauging Stations in Tana Basin Area

No.	SRO in charge	Telemeterized:T	Data Logger:DL	Station ID	Station Name	Type of station	Lat.	Long	Status	Gauge Reader	Remarks	Site Visit	Key for Telemetering Stn.	Q mes. & Survey	Vandalized
26	Muranga			4BF01	Saba Saba	IMU	-0.864	37.264	Operational	Yes	Under the bridge with less discharge. Much sedimentation is expected. SRO requesting upgrading to telemetering station.	09 July 2021 by Okamura, Kato			
27	Muranga			4BC04	Rwamuthambi	IMU	-0.66454	37.24068	Operational	Yes	Under the bridge along highway. The bridge being reconstructed for widening the road. Need relocation of the gauge.	09 July 2021 by Okamura, Kato			
28	Muranga			4BD01	Mathioya	IMU	-0.7144	37.18028	Not Operational	No gauge reader	Vandalized in 2019. 1st staff gauge stolen.				V
29	Muranga	T		4AB06	Amboni	Special	-0.39961	36.99217	Operational	No gauge reader	Telemeterized by KMD in March 2022.				
30	Muranga			4AB01	Muringato	Special	-0.40246	36.94538	Operational	Yes	Needs to be automated.				
31	Muranga			4AA05	Sagana	Special	-0.44298	37.04286	Operational	Yes	Data logger not in function. Nairobi Water Fund installed the data logger in 2019but not functioning since 2020. Needs rectification.				
32	Muranga			4CC03	Yatta furrow	Special	-1.09228	37.36165	Operational	Yes	There is another station close to this one. Needs to be abandoned.				
33	Muranga			4CB05	Thika Inflow Ndakaini	Special	-0.80205	36.80925	Operational	No gauge reader	Dam operator read the staff gauge and share the data with WRA				
34	Muranga			4BE03	Irati	Special	-0.78459	37.01089	Operational	Yes	Needs to be telemeterized. Located at downstream of Northern Collector. Upstream of Muranga Water Service Provider's intake.				
35	Muranga			4BE8	Gikigie	Special	-0.72353	36.84182	Operational	Yes	Needs to be telemeterized. Upstream of Northern Collector Tunnel.				
36	Muranga			4BD MISC	Githugi	Special	-0.61743	36.8536	Operational		1st staff gauge vandalized in 2020. Needs reinstallation.				V
37	Muranga			4BD07	N.Mathioya	IMU	-0.62787	36.95525	Operational	Yes	1st staff gauge is faded. Needs reinstallation.				
38	Muranga			4CA05	Sasumua	Special	-0.72576	36.64697	Operational	by NBO water supply	Dam operator read the staff gauge and share the data with WRA				
39	Muranga		DL	4CA3	Chania	Special	-0.84904	36.80014	Operational	Yes	Data logger				
40	Muranga			4AA2	Thegu	Special	-0.34596	37.0478	Operational	Yes	Nairobi Water Supply Data Logger HOB0 is not working.				
41	Muranga	T		4AA4	Nairobi	Special	-0.35458	37.007111	Operational	Yes	KMD telemeterized in March 2022.				
42	Muranga	T		4CB7	Thika	Special	-0.82174	36.86533	Operational	by NBO water supply	Nairobi Water Supply Project read the data and share with WRA. Telemeterized by Nairobi Water Supply Project.				
43	Muranga	T		4CA19	Kariminu	Special	-0.87286	36.79152	Operational	Yes	KWSCR P telemeterized in 2018.				
44	Muranga			4CA11	Kimakia	Special	-0.86602	36.85994	Operational		Nairobi Water Fund installed telemetering system but vandalized together with solar system. 1st staff gauge also vandalized.				V
45	Muranga		DL	4BE4	Kayahwe	Special	-0.02835	37.05208	Operational	Yes	Data logger HOB0 is installed by Nairobi Water Fund.				
46	Muranga			4AA01	Sagana	Special	-0.36167	37.0679	Operational	Yes	1st staff gauge is deteriorated. Needs to be rehabilitated.				
47	Muranga			4CC5	Thika at Delmonte Bridge	Special			Not Operational	No gauge reader	1st staff gauge is missing. The staff gauge is disturbed by road expansion works. Needs relocation.				
48	Muranga			4CB8	Thika at Ruchu	Special			Not Operational	No gauge reader	1st staff gauge is faded. Needs reinstallation. WRA intends to install Data Logger provided by JICA. WRA requests guidance from JICA or others.				
49	Muranga		DL	4CB6	Githika	Special	-0.7989	36.8344	Operational	by NBO water supply	Nairobi Water Supply Project read the data and share with WRA. Nairobi Water Supply installed HOB0 Data Logger.				
50	Muranga			4AD06	Gikira	Special	-0.57292	36.91756	Not Operational	No gauge reader	Only one staff gauge washed away. Needs reinstallation with concrete post type staff gauge.				

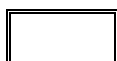
Status of Regular Gauging Stations in Tana Basin Area

No.	SRO in charge	Telemeterized:T	Data Logger: DL	Station ID	Station Name	Type of station	Lat.	Long	Status	Gauge Reader	Remarks	Site Visit	Key for Telemetering Stn.	Q mes. & Survey	Vandalized
51	Muranga		DL	4BE	Githanja	Special	-0.78984	37.12922	Operational	Yes	Relocated 500m. Measured by Nairobi Water Fund for reparation erosion and sedimentation. HOBO Data Logger is installed.				
52	Muranga		DL	4CB	Kiama	Special	-0.8319	36.81815	Operational	Yes	Measured by Nairobi Water Fund. HOBO Data Logger is installed.				
53	Muranga		DL	4AD	Mumwe	Special	-0.51729	36.94088	Operational	Yes	Measured by Nairobi Water Fund. HOBO Data Logger is installed.				
54	Muranga		DL	4CA	Mbogiti	Special	-0.83977	36.82812	Operational	Yes	Measured by Nairobi Water Fund for reparation erosion and sedimentation. HOBO Data Logger is installed. A lot of sediment. Needs relocation.				
55	Muranga		DL	4CA	Karangi Kiana	Special	-0.82595	36.80302	Operational	Yes	Measured by Nairobi Water Fund. HOBO Data Logger is installed.				
56	Muranga		DL	4CB	Thika Valley/Ndiara	Special	-0.79176	36.80548	Operational	Yes	Measured by Nairobi Water Fund. HOBO Data Logger is installed.				
57	Muranga			4BE	Githambara	Special	-0.80988	37.07202	Not operational	No gauge reader	Staff gauge is affected by road construction works. Needs relocation/rehabilitation.				
58	Muranga		DL	4BE	Kaharo/Karurumo	Special	-0.79624	37.08675	operational	Yes	Measured by Nairobi Water Fund. HOBO Data Logger is installed.				
59	Muranga		DL	4AA	Kamahuri	Special	-0.29789	37.1125	operational	Yes	Measured by Nairobi Water Fund. HOBO Data Logger is installed.				
60	Muranga		DL	4AD	Mitai	Special	-0.58407	36.90605	operational	Yes	Measured by Nairobi Water Fund. HOBO Data Logger is installed.				
61	Muranga		DL	4AD	Marogoya	Special	-0.56169	36.87556	operational	Yes	Measured by Nairobi Water Fund. HOBO Data Logger is installed.				
62	Muranga		DL	4AD	Gathanji	Special	-0.52853	36.86218	operational	Yes	Measured by Nairobi Water Fund. HOBO Data Logger is installed.				
63	Muranga		DL	4AB	Rongai mainroad station	Special	-0.23376	37.015295	operational	Yes	Measured by Nairobi Water Fund. HOBO Data Logger is installed.				
64	Muranga		DL	4AB	Rongai vellaage 7 Station.	Special	-0.260787	36.969532	operational	Yes	Measured by Nairobi Water Fund. HOBO Data Logger is installed.				
65	Muranga		DL	4AA	Gatubia	Special	-0.52853	36.86218	operational	Yes	Measured by Nairobi Water Fund. HOBO Data Logger is installed.				
66	Muranga			4BD9	S.Mathioya	Special			operational	Yes	Needs upgrading to telemetering.				
67	Meru			4F13	TANA GRAND FALLS	Special	-0.26614	38.012	Not operational		Not Upgraded				
68	Meru			4F31	Kathita	Others	-0.02516	37.58807	Operational						
69	Meru		DL	4F10	Kathita	Intra	-0.15505	37.97527	Operational	Yes	Data Logger installed by JICA.	08 July 2021 by Okamura, Kato		O	
70	Meru			4F17	THINGITHU	Intra	-0.1759	37.96917	Not operational		Not Upgraded				
71	Meru			4F4	Thingithu	Others	-0.05894	37.65932	Operational						
72	Meru			4EA7	Mutonga	MU	-0.05894	37.65932	Operational		Not Upgraded				
73	Meru			4EB9	Tungu	IMU	-0.30515	37.66147	Operational	Yes					
74	Meru	T	DL	4EA3	Kithino	Special	-0.37613	37.89554	Operational		Data Logger installed by Kenya Climate Smart Agriculture Project (KCSAP) in March 2022.				
75	Meru	T	DL	4EA6	Mutonga	IMU	-0.30607	37.87245	Operatoinal	Yes	Automated /Data logger sensor washed by the floods in April 2019. KCSAP installed a new one in March 2022.				

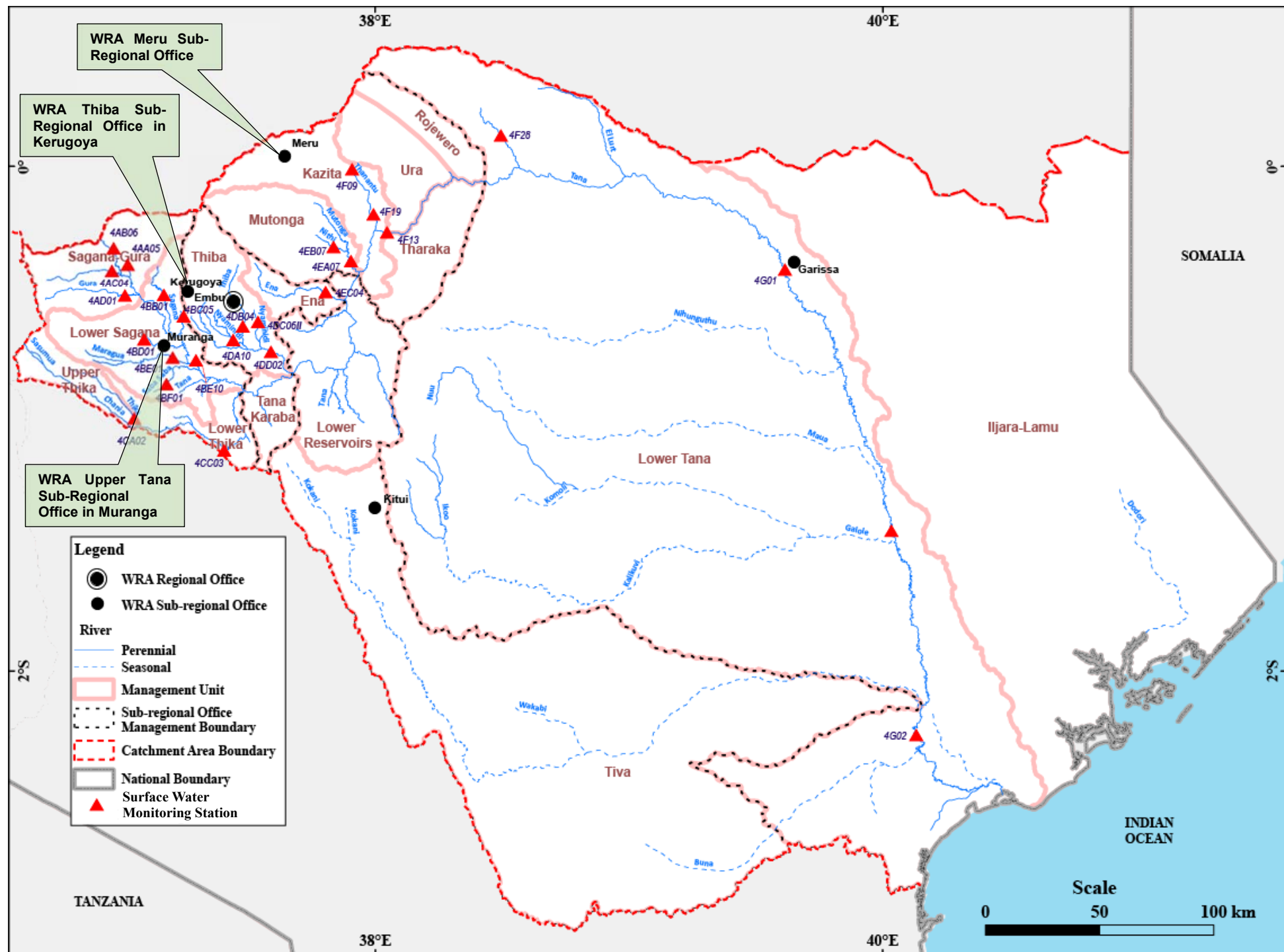
Status of Regular Gauging Stations in Tana Basin Area

No.	SRO in charge	Telemet erized:T	Data Logger: DL	Station ID	Station Name	Type of station	Lat.	Long	Status	Gauge Reader	Remarks	Site Visit	Key for Telemeter ing Stn.	Q mes. & Survey	Vanda lized
76	Meru			4F8	THANGATHA	Special	-0.30515	37.66147	Not operational		Not Upgraded/Needs rehabilitation				
77	Meru			4EB6	Ruguti	IMU	-0.34734	37.86838	Operational	Yes					
78	Meru			4EB12	S. Maara	others	-0.26383	37.6624	Operational	Yes					
79	Meru			4EB11	Maara	others	-0.37562	37.58892	Operational						
80	Meru			4F20	Thanantu	IMU	-0.09126	38.02732	Operational	Yes					
81	Meru			4F09	Ura	IMU	-0.34734	37.86838	Operational	Yes					
82	Meru	T	DL	4EB07	Thuchi				Operational	Yes	Data Logger installed by Kenya Climate Smart Agriculture Project (KCSAP).				
83	Garissa			4F28	Rujii Rweru	Special	-0.21591	38.06086	Not Operational		Not Upgraded				
84	Garissa			4F16	Tana	Special	-0.26383	37.6624	Not operational		Not Upgraded				
85	Garissa	T		4G01	Tana Garissa	National	-0.463848	39.636621	Operational	Yes	Manual and telemetric in place				
86	Garissa			4G04	Tana-Hola	MU	-1.492893	40.036625	Operational		Not upgraded				
87	Garissa			4G02	Tana_Garsen	IMU	-2.288736	40.126703	Operational		Not upgraded				

	22	23													8
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: Proposed Gauging Station in National Water Master Plan 2030



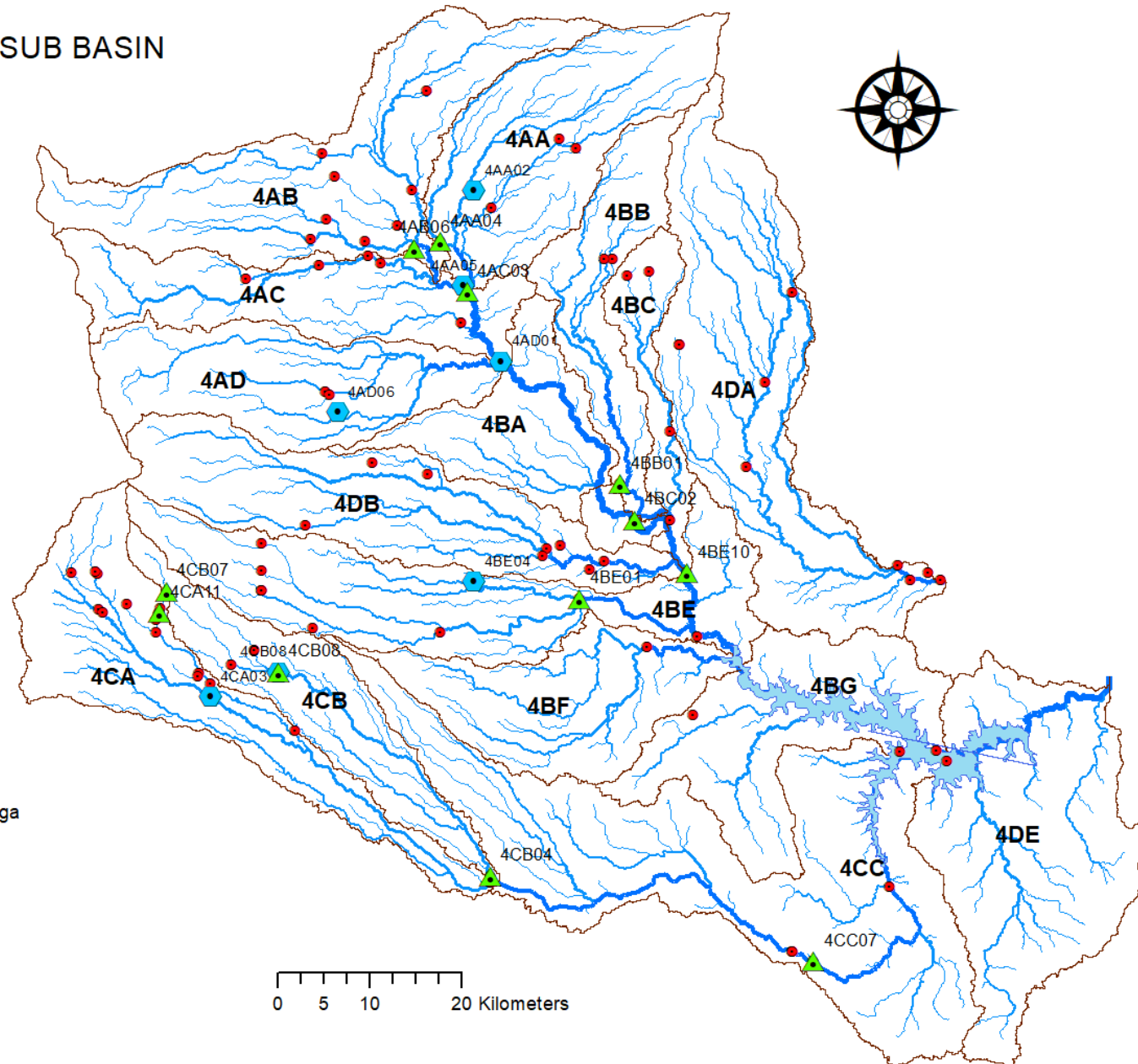
MURANGA SUB BASIN

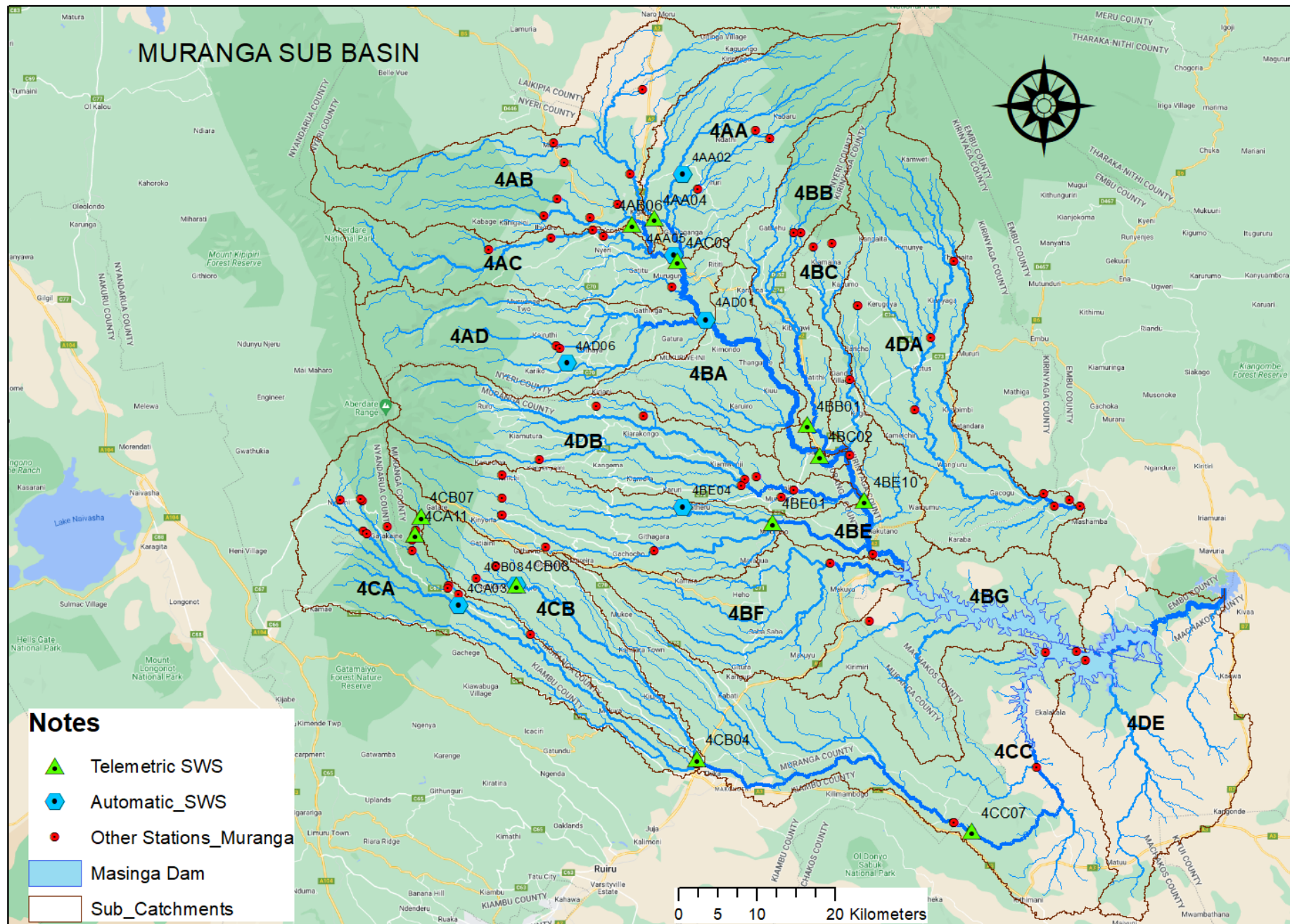


Notes

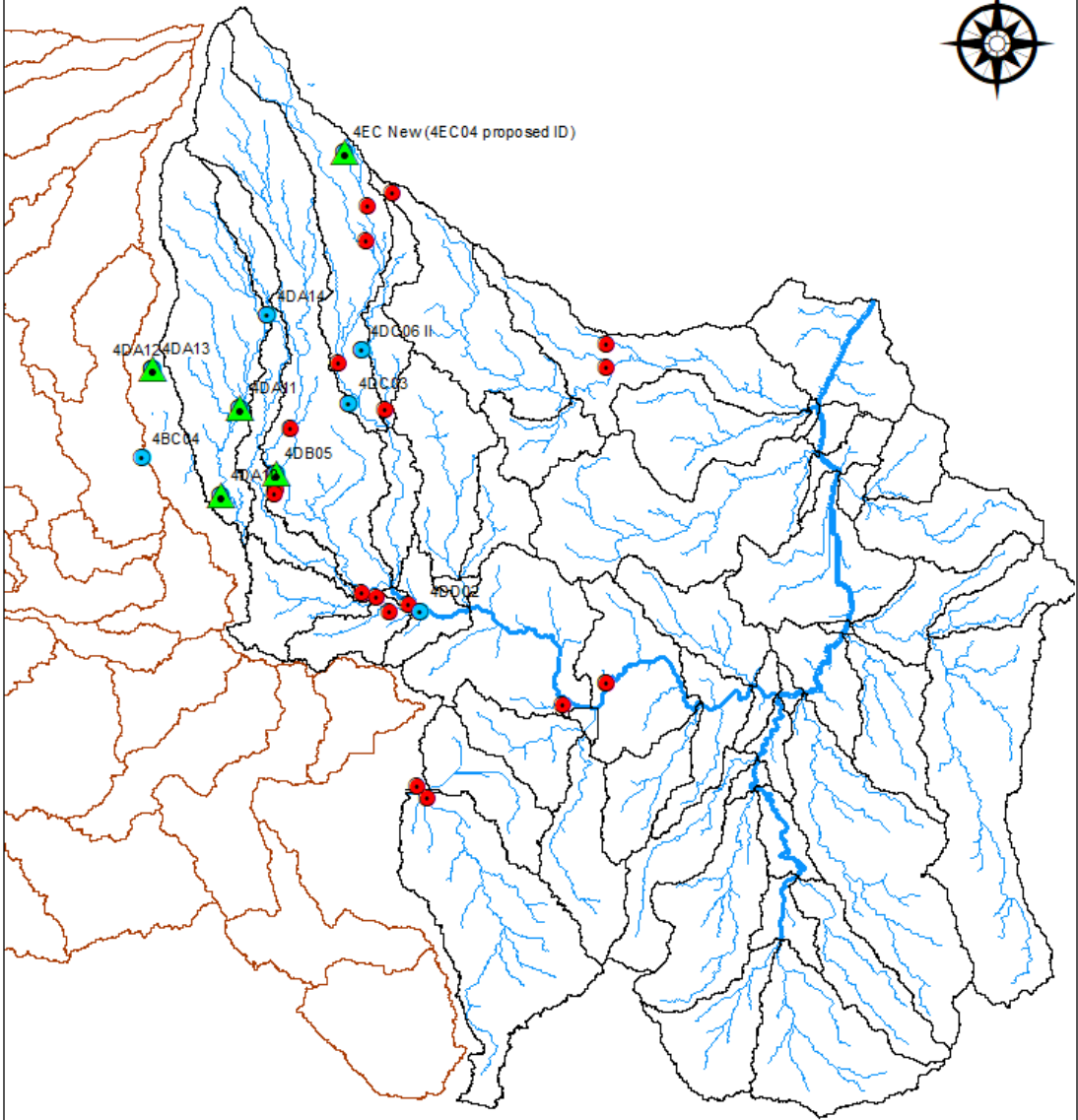
- Telemetric SWS
- Automatic_SWS
- Other Stations_Muranga
- Masinga Dam
- Sub_Catchments

0 5 10 20 Kilometers





KERUGOYA SUB BASIN



Legend

- Telemetric_Stations
- Manual Stations
- Kerugoya_Sub_cat
- Other Stations

0 5 10 20 Kilometers

