

Appendix 7

Change of Telemetric Observation Station for Capacity Building on Flood Monitoring

1. Background

Among the JICA advisory work activities, regarding "Output 4: Strengthening the ability to analyze and utilize meteorological and hydrological data," there is an item "Activity 4-3: Discussion and organization of the role of WRA and the utilization of monitoring results for flood level damage reduction."

In the work plan, it is mentioned that:

"In order to reduce flood damage, it is possible to issue warnings through the transmission of observation data, collection and recording, and analysis, which the WRA has so far carried out. JICA Experts Team will investigate the situation on the ground together with WRA headquarters staff, staff from the Tana Basin Office, and sub-basin office staff to obtain information on the necessary equipment, target observatories, and related organizations to collaborate with." The JICA Experts Team has been proceeding with discussions with the WRA so far.

As a result, it was examined that some type of flood forecasting and warning system, such as telemeter equipment, to be installed at the observation station at "4F13 Tana Grand Falls," located approximately 200 km upstream of Garissa, in order to provide flood warnings to Garissa and its downstream areas, where flood damage is expected. JICA Experts Team also considered to use it for flood prevention in downstream areas. It was also planned to build the capacity of WRA staff to operate such equipment.

2. Study results

As a result of the inspection of the 4F13 site during the field survey in May 2023 by the Team Leader and the telecommunication expert, it was found appropriate that the use of a coin-type sensor to detect flood levels was easy to install and easy to maintain. A schematic diagram of the system is shown in Figure 1.

Coin-type sensors are being tested in some municipalities in Japan for the purpose of sensing flood levels, and were decided to be adopted at the 4F13 observation point because they can be easily installed by simply attaching them to the existing water gauges/structures. JICA Experts Team considered this and requested estimates from several companies, including manufacturers in Japan. However, it was realized that installation and operation within Kenya would be difficult for the following reasons.

- Many of the coin-type sensors in Japan, which are designated for adaptation at 4F13, are prototypes because they are used for demonstration tests, and new designs are required for deployment in overseas markets, which requires additional costs and time. In addition, most of the prototype coin-type sensor would be verified for the actual usage and would be rectified.
- As a technical issue, when applying low power consumption communication to replace Bluetooth

that us designated data transmission between the coin-sensor and the router, it is necessary to obtain certification for frequency use in Kenya (takes time).

- Similarly, 4G/LTE was assumed to be used to transfer data to the WRA office, but it would be costly to change to 4G/LTE (European specifications) in Kenya (transferring from the Japanese specifications to the European specifications).
- Manufacturers in Japan create their systems in Japanese, making it difficult to convert them into English and it requires the additional cost and time.

As an alternative, we considered installing a pressure sensor and telemetering system like other water level observation stations, but since the river width at 4F13 is more than 100m during floods, it was necessary to install pressure sensors and cables. The conclusion was reached that it would be difficult to implement the system because the civil engineering work would be extensive, construction supervision for installation would take time, and the construction cost would exceed the budget for expert activities. For this reason, we decided that we had no choice but to abandon the installation of a flood forecasting and warning system at “4F13 Tana Grand Falls.”

In addition, according to a report in the online version of the local newspaper “Nation” on September 21, 2023, the development of the Grand Falls Dam will soon begin under British leadership, and in that case, the observation point will be affected by the dam construction. It is expected that operations will be disrupted. It was decided not to install a flood forecasting and warning system for the purpose of capacity building at the 4F13 site, as it would not be possible to operate sustainably in the future. Capacity building regarding telemetering equipment is planned to be carried out using the existing telemetering equipment in the telemetric stations.

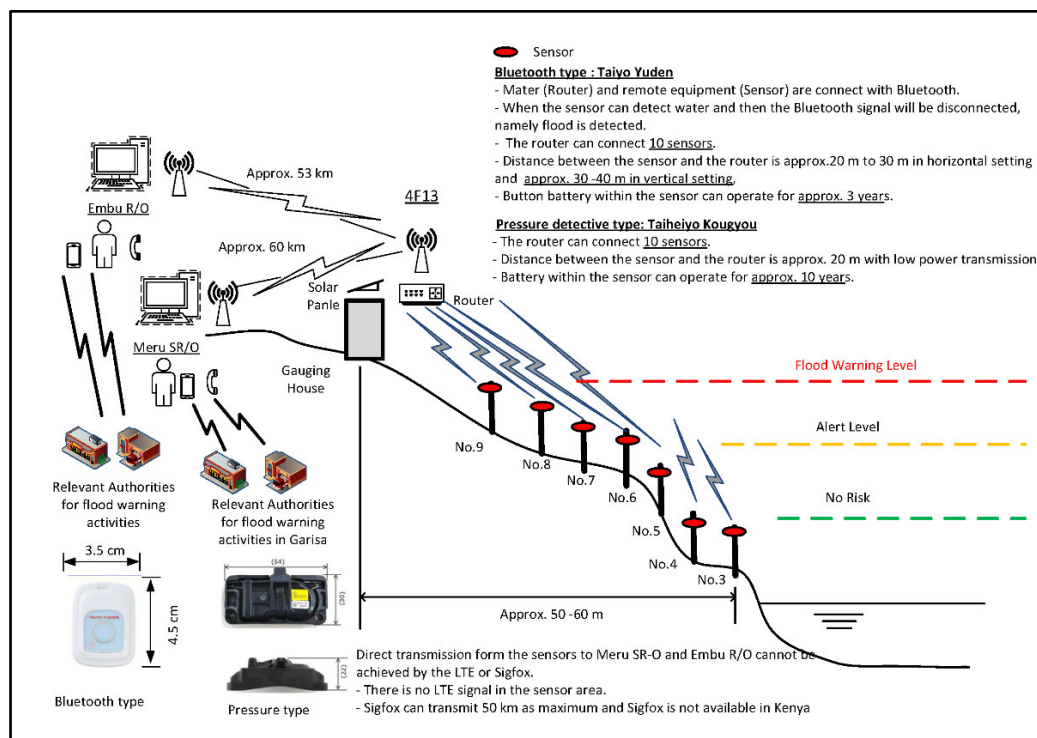


Figure-1 System diagram of coin type sensor for flood level sensing

Appendix 8

Upper Tana Nairobi Water Fund Strategic Plan 2022-2026

UPPER TANA-NAIROBI WATER FUND

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STRATEGIC PLAN 2022–2026



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Prepared by:



LIST OF ACRONYMS

BoM	Board of Management
BoT	Board of Trustees
CAC	Counties Advisory Committee
CMS	Cubic Meters per Second
GDP	Gross Domestic Product
ICRAF	International Centre for Research in Agroforestry
IFAD	International Fund for Agriculture Development
IOD	Indian Ocean Dipole
JKUAT	Jomo Kenyatta University of Agriculture and Technology
KenGen	Kenya Electricity Generating Company
Ksh	Kenya Shilling
M&E	Monitoring and Evaluation
NCWSC	Nairobi City Water and Sewerage Company
NGO	Nongovernmental Organization
PESTEL	Political Economic, Socio, Environmental, and Legal
PPP	Public-Private Partnership
SLM	Sustainable Land Management
SSP	Shared Socioeconomic Pathway
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TNC	The Nature Conservancy
TSS	Total Suspended Solids
USD	United States Dollar
UTNWF	Upper Tana-Nairobi Water Fund
WF	Water Fund
WRA	Water Resources Authority

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PRESIDENT'S FOREWORD

On behalf of the Board of Trustees and Management of the Upper Tana-Nairobi Water Fund (UTNWF) Trust, I am pleased to present the Trust's Strategic Plan for the period 2022–2026. This plan is a result of synthesis and integration of accomplishments and lessons learned over the last five years as they relate to the mandate of the Trust as envisaged in the incorporation Trust deed. This plan is a statement of intent about how the Trust, operating independently as of 2022, will continue to support the long-term conservation, protection, and maintenance of the Upper Tana watershed and thereby improve Nairobi's water security and optimal functioning of Seven Forks hydropower generation plants along the Tana River. It also indicates the efforts that will be undertaken "to mobilize and efficiently deploy resources for sustainable and innovative conservation in the Upper Tana, resulting in improved livelihoods and safeguarded river water quality and quantity." Equally, the strategic plan establishes specific goals aimed at achieving the Trust's vision and mission of ensuring a well-conserved and managed watershed for sustained better life in the region and beyond.

The Trust brings together public and private sectors to work together in partnership and deliver collaborative solutions throughout the Upper Tana watershed for one of the greatest challenges to our future: source water protection. The Upper Tana watershed supports 95% of the water supply for Nairobi City and generates 65% of the nation's hydropower. The plan also identifies and assesses the Trust's strengths, weaknesses, threats, and opportunities, as well as identifies specific five-year strategic objectives that will be achieved through a series of strategic initiatives and detailed tasks to help us realize our vision and achieve the Trust's strategic goals. During the strategic planning process, the Trust refined its vision to align with the aspirations espoused in the Trust deed, the 2015 UTNWF business case, the country's development agenda, and the world's desire to achieve the United Nation's Sustainable Development Goals. The Trust's four strategic focus areas that will drive it in realizing its vision are customer focus, financial plausibility, sound internal processes, and sustained organizational capacity. Successful implementation of the strategic plan will depend on the leadership, senior management and all staff fully embracing it and committing themselves to its attainment. I therefore call on all of us to work together to effectively conserve the source water areas and to sustain water supply security to Nairobi while at the same time ensuring sustainable livelihoods of the millions of communities living in Upper Tana and beyond so that this plan can be realized. I am confident that we shall effectively tackle any issues that may arise and thus make a visible contribution to the broader environmental and human development and to our prosperity.

As a trust, we are fully committed to implementing the clearly articulated goals in this plan. We commit to working with all stakeholders to continually develop appropriate policies and review the Trust's work and operations to ensure smooth, successful implementation of this plan. I commend all those who gave their invaluable input, and more specifically the Board of Management and staff of the Trust who worked tirelessly to produce the UTNWF Strategic Plan.

Eddy Njoroge, E.B.S., C.B.S.

President, UTNWF Board of Trustees

PREAMBLE

I am pleased to present the Strategic Plan of the UTNWF for the period 2022–2026. This strategic plan is the culmination of an all-inclusive consultative process that involved our Board of Management, Trustees, staff, and other stakeholders. The plan incorporates lessons learned over the past five years, reviews past challenges, present new ones, and outlines the future for the Trust. The plan articulates a comprehensive road map for the next five years and outlines the Trust's short- and medium-term strategies. I urge staff to study and internalize the plan so that we can deliver on the targets set out therein. Going forward, our trust and individual performance commitments, as well as resource allocation, shall be based on this plan. To our stakeholders, this plan will serve as a yardstick for evaluating our performance as a trust and how responsive we are toward environmental, social, human, conservation, and development needs.

In developing this plan, the Trust considered several important factors to ensure that it is anchored on the prevailing government policies, national development plans, and the law. The most notable was that the UTNWF has attained maturity stage, according to the water fund development cycle. This follows a successful incubation phase managed by The Nature Conservancy (TNC). This plan refreshes the Trust's priorities and strategic objectives to fully meet the business case goals and targets, and provides the building blocks for the Trust's organizational, financial, and operational sustainability. This plan considers both the internal and external environment that the Trust operates in. It also incorporates contributions from diverse stakeholders and the lessons learned in the past to develop three strategic focus areas. Successful implementation of this plan calls for prudent leadership to enhance efficiency, effectiveness, and greater client orientation. Through this process, the Trust has identified a set of values that provide the cultural foundation required to align ourselves to the new strategy.

I am happy that given the consultative process we went through in developing this strategic plan, there is common understanding, common ownership, and common commitment to its implementation. As the chairman, I commit the BoT and by extension the BoM and CAC to remain the custodians and drivers of the implementation process, keeping the directors and key staff focused on the intended results to provide an enabling environment for success. On behalf of the Trust, I wish to express my gratitude to all those who participated or supported us as we developed this strategic plan. It was an exacting but nevertheless fruitful process. I have every confidence that we will deliver on this plan and thus make a positive contribution to source water protection, community livelihoods, clean water supply, and the economy of this country.

Emmanuel Rurema

Chairman, Board of Trustees, UTNWF Trust

EXECUTIVE SUMMARY

The Upper Tana-Nairobi Water Fund Trust is registered as a public charitable trust in Kenya with the following **Mission**: To secure the long-term conservation, protection, and maintenance of the Upper Tana watershed and the benefits it provides for people and nature by advancing nature-based solutions to water security. The UTNWF's **Vision** is "a well-conserved and managed Upper Tana watershed that sustains healthy livelihoods and ecosystem functions in the region and beyond, with the **Goal** to support the long-term conservation, protection, and maintenance of the Upper Tana watershed and thereby improve Nairobi's water security and optimal functioning of hydropower facilities along the Tana River.

The purpose and objective of this Five-Year Plan is to

- **Create Clarity** — Establishing a framework for documenting and evolving important strategic choices made by the trust leadership.
- **Provide Focus** — Allowing for more effective goal setting and purpose-based leadership by the trust.
- **Develop a Shared Road Map** — Driving measurable progress toward impact and systemic change.

The Upper Tana watershed is among the most important in Kenya for water supplies, agricultural production, and biodiversity conservation. The watershed supports 95% of the water supply for Nairobi City and generates 65% of the nation's hydropower. Over the next five years and beyond, the goals of the trust will be to significantly increase its investments to improve water quality and quantity in the Upper Tana watershed, enhance food security, protect freshwater and terrestrial biodiversity, and improve human well-being of local communities. This will be achieved by implementing four strategic objectives: enhancing the climate change resilience of biodiversity and ecosystem function in the Upper Tana; improving socioeconomic conditions for local and regional communities; increasing water supply and quality with enhanced resilience to climate change; and establishing effective policies, knowledge sharing systems, and sufficient funding to sustain water and land conservation activities in the Upper Tana. Achieving these objectives will include increasing the capacity and accountability to trust stakeholders; establishing robust data collection and sharing systems as part of monitoring, evaluation, and adaptive management; improving policies and investments of local governments and partners; strengthening trust institutional capacity; and securing an operating endowment that can sustain the work of the trust indefinitely.

The Trust is set up as a public-private partnership working collaboratively throughout the Upper Tana watershed on solutions for one of the greatest challenges to our future: source water protection. The Trust is an incorporated charitable trust in Kenya, governed by a board of trustees (BoT), board of management (BoM), and counties advisory committee (CAC), all of which oversee the work of staff and are led by a full-time executive director. In addition, over the first five years of operation, the Trust has established robust partnerships with local nongovernmental organizations (NGOs), government agencies, and research institutions to assist with and guide the implementation of watershed management. The Trust is now in a transition phase and will

operate independently as of September 2021. The Trust has developed the necessary management systems, human resources, financial management, and operational systems necessary to operate as an independent entity. The strategic plan, therefore, will guide the Trust by clarifying its strategic objectives and priorities over the next five years, and by providing a road map for implementation and monitoring to ensure the Trust remains focused on delivering outcomes for the Upper Tana watershed and downstream water users. The plan will also provide the foundations for Trust leadership, key partners, staff, and stakeholders to measure progress and adjust programs as necessary to focus and consolidate the work of the Trust for the next five years.

Introduction

Tana River Watershed and Regional Context

The Tana River is perhaps Kenya's most important river. It is the country's longest river — stretching almost 1,000 km from the edge of the Great Rift Valley to the fertile delta where it meets the Indian Ocean. A healthy Tana River is a significant contributor to Kenya's diversity and sustainability (Figure 1).

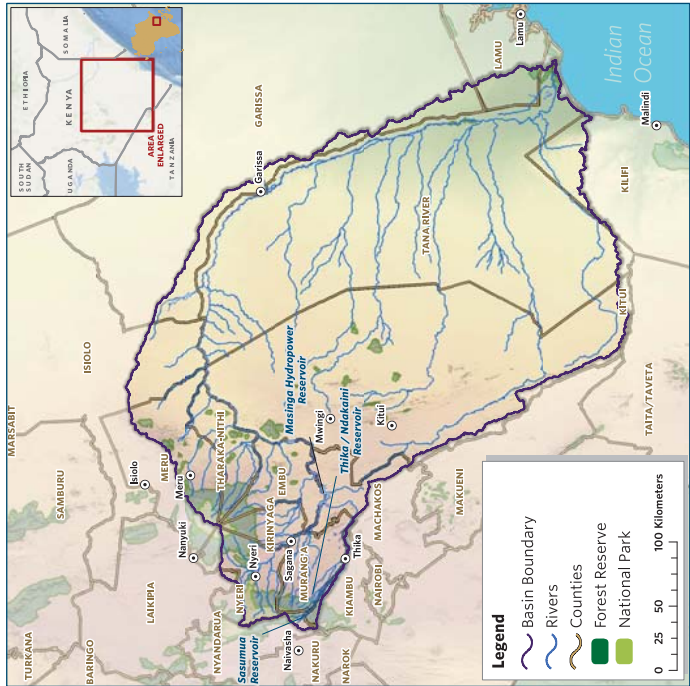


Figure 1: Tana River watershed.

The Tana sustains important aquatic biodiversity, provides water to key national parks, generates half of the total hydropower in the country,¹ and supplies 95% of Nairobi's wealth and water for

¹ Vogl et al. (2016). Valuing investments in sustainable land management in the Upper Tana River basin, Kenya.

a population of over 6 million people.² The water from the Tana is also the basis for Kenya's most productive agricultural area, driving agricultural activities that feed millions of Kenyans, and supporting over 300,000 smallholder farms along its course.

The Upper Tana basin is also among the most important for the people of Nairobi and Kenya for several reasons. The Upper Tana covers approximately 17,000 km² (the equivalent of 3 million football fields), including three catchments and two of Kenya's most important sources of water — Mount Kenya and the Aberdare Range (Figure 2).

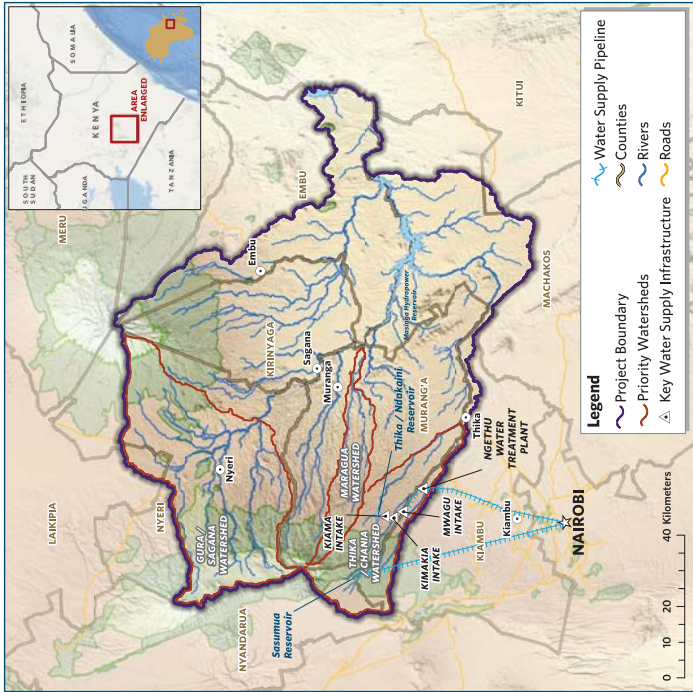


Figure 2: trust project area.

The Upper Tana supports over 5 million people in the counties of Kirinyaga, Murang'a, Nyeri, Nyandarua, Laikipia, Kiambu, Embu, and Machakos.

² 2019 Kenya Population and Housing Census. Volume 1.

Agriculture is the backbone of Kenya's economy, contributing approximately 25% of the gross domestic product and employing 75% of the national labor force. The Upper Tana is no exception; thousands of smallholder farmers produce diverse crops in this watershed, including coffee, tea, macadamia nuts, avocados, Asian vegetables, potatoes, rice, citrus fruits, mangoes, arrowroots, maize, and beans. These crops are grown both for their importance for subsistence of local people and as cash crops. Given that approximately 80% of the Kenyan population lives in rural areas and makes a living directly or indirectly from agriculture, improving agricultural management and the resilience of farming communities in the Upper Tana through protection of clean water supplies will not only be important for these local communities, but also be an important contribution to Kenya's wealth and resilience.

The Upper Tana is also a crucial energy resource because it drains directly into the Seven Forks hydroelectric generation systems, with reservoirs at Masinga and Kamburu. The Seven Forks system generates 65% of Kenya's hydropower, which is a significant portion of the energy for Kenya overall. This is becoming increasingly important for Kenya's sustainable development. Biomass energy currently provides over 80% of Kenya's national energy needs, and demand for wood fuel already exceeds sustainable supplies, compromising both people's access to energy and the forested ecosystems from where this wood is collected. Thus, maintaining or even increasing the energy production of the Seven Forks dams will be essential for the region and the country in the coming decades. Also, developing and demonstrating improved watershed management and conservation to protect water supplies and energy production will provide a vital demonstration of how to improve energy and water sustainability that can be a model for Africa and the world.

It's not only people that depend on a healthy Upper Tana. This region is home to a rich diversity of plants and animals. The forests in these important but fragile mountain ecosystems are key sources of food, cover, and water, and they serve as migration routes and habitat connectors for a variety of wildlife. Several different kinds of forest characterize the watershed, each hosting a diversity of species. These forests are complemented by the river ecosystems, wetlands, and grasslands that create a mosaic of habitats providing the resources that hundreds of different kinds of wildlife depend on for their survival. Both Mount Kenya and the Aberdares are protected within a national park. They share many ecological affinities with each other and the surrounding, unprotected landscapes. Collectively, these watersheds support most of the country's surviving Afro-montane forest and Afro-alpine moorland, the latter an otherworldly landscape of open moorland studded with bizarre, giant forms of heather, lobelia, and groundsel. The two mountains host an outstandingly varied fauna, including the big five (lion, leopard, elephant, rhinoceros, and cape buffalo), alongside more localized forest species such as Sykes' monkey, the black-and-white colobus, Harvey's red duiker, mountain antelope, and the giant forest hog. The Aberdare Range is also one of the few places in Africa where melanistic (all black) leopard sightings are common, and its forests support one of only two remaining wild populations of the mountain bongo, a large, beautifully marked critically endangered forest antelope that is now effectively endemic to Kenya, having become extinct elsewhere.

The health and survival of this wild diversity will depend on maintaining sustainable land and water management in the basin. The importance of these diverse ecosystems to people cannot be understated. They deliver valuable ecosystem services that inhabitants of the Tana basin and beyond depend on. The forests help control water pollution, reduce erosion, mitigate floods, and increase groundwater recharge. They also attract wildlife tourism — an important economic driver in Kenya that depends on rich biological diversity. Tourism accounts for 10% of Kenya's GDP and 9% of total formal employment. The Tana basin overall contains several protected areas, including four national parks and eight game reserves. Mount Kenya National Park is listed as a UNESCO World Heritage site and alone receives over 15,000 visitors per year. The long-term health and beauty of Mount Kenya National Park and the other protected areas will depend on the health of water and land surrounding them. Thus, enhancing the health and resilience of the Upper Tana and surrounding regions has the potential to both enhance the region's importance for biodiversity and increase tourism and associated economic development to provide alternative sources of income and livelihood for residents.

The region's biodiversity provides even more direct ecosystem services for local communities than tourism does. Most directly, the water and soils of the basin are the lifeblood of productive agriculture in one of Kenya's most important agricultural regions. Degradation of either of these precious resources over time will lead to a collapse of the agricultural economy and the livelihoods of millions of people in the region. Also, most Kenyans living in rural areas depend on medicinal plants for treating various ailments. With increasing exploitation of medicinal plants, demand for their sustainable management and utilization is rising. Protecting endangered plant and animal species and securing water resources from adverse impacts of pollution are crucial to enhancing and maintaining these natural resources.

Water Security Challenges and Consequences

The vegetation in the Upper Tana watershed plays a critical role in maintaining water quality and quantity, providing areas where runoff water is stored and sediment is naturally filtered. However, several factors — the conversion of forests to agriculture and unsustainable agricultural management practices chief among them — have contributed to the degradation of the river and surrounding lands, threatening the benefits of a healthy and diverse watershed. Since the 1970s, most of the unprotected forests and woodlands — including those on steep hillsides, along rivers, and wetlands — have been converted to agriculture so that now most of the landscape is covered in herbaceous (33.24%) and shrub (14.68%) crops like tea, coffee, and corn. Along with this conversion has come increased demand for irrigation water from a growing number of river diversions that reduce available river flows that sustain downstream users and hydropower generation. Rain-fed smallholder agriculture now uses 36% of the available water, and irrigated agriculture uses an additional 4%. Hydropower generation depends on 33% of the available water in the watershed; however, this use is non-consumptive since the water is returned to the river after being used for power generation (Figure 3).



Figure 3: Annual water use by those who depend on the water supply of the Upper Tana River basin above Masinga Dam (WRMA, 2011).

This rapidly increasing demand is severely reducing dry season river flow, not only because of diversions, but also because the Upper Tana's dry season flows depend on groundwater. The conversion of natural wetlands that once stored runoff water and recharged groundwater supplies to agriculture is reducing groundwater availability, further reducing dry season flows. Increasing demand and decreasing water supply in the river is consequently increasing local conflicts among different water users in and downstream from the watershed.

In addition to reduced river flows, water quality is declining. Unsustainable farming practices are causing widespread soil erosion, degrading farmland productivity and — combined with increasing competition for space — forcing farmers onto steeper and steeper slopes, where erosion is an even larger problem. Increased sedimentation is reducing water quality for both residents and downstream users, with important social and economic implications. Increased sediment in the river reduces the quality of drinking water available to people and increases maintenance and water treatment costs for water providers. Nairobi City Water and Sewer Company (NCWSC), the major water and sewerage service provider for Nairobi, reports that water treatment costs increase by more than 33% as sediment runoff fills and disrupts treatment equipment during the wet season, causing supply interruptions. Without intervention, this problem will likely worsen, especially as climate change causes more intense rainfall events and population growth leads to more farming on steep slopes.

These impacts are coming at a time when Nairobi's water treatment and distribution facilities are already under pressure. The current water supply deficit for the city stands at 299,000 m³ per day (or 36% of demand) when the system is operating at full capacity. New capacity added to address these shortages must also face the challenges and costs associated with high sediment loads in the water.

Furthermore, sediment deposition in reservoirs and reduced dry season flows are also a problem for hydroelectric energy production by Kenya Electricity Generating Company (KenGen). KenGen,

the country's leading electric power generation company, operates several hydropower dams in the Tana watershed. The Masinga reservoir, for example, was designed on the basis of a siltation rate of 3 million tons per year. However, by 2010, the annual siltation rate was 6.7 million tons. As a result, the Masinga reservoir has already lost an estimated 158 million m³ of storage volume, 10% of its capacity since 1981.³ Similarly, the other major hydroelectric reservoir in the system, Kamburu, is estimated to have lost 15% of its capacity since 1983. This lost capacity substantially reduces the energy production potential of these important renewable energy sources for Kenya. As dry season flows decrease, the amount of energy that can be produced is significantly reduced. For example, during the 2009 drought, KenGen's electricity production dropped 12% compared with the previous year, a decline of \$19.8 million.⁴

Water quality for residents is also being compromised by development and agricultural production in the landscape beyond just the effects of sedimentation. Livelihoods and health are being adversely affected by reduced drinking water quality and increased probability of waterborne disease. Surface and groundwater quality is affected by new and expanding settlements, especially informal settlements, towns, and markets that do not have conventional sewer systems and, as a result, are polluting nearby ground and surface water bodies. Wet coffee milling factories add pollution to the river if not managed sustainably, and other agricultural activities contribute pesticides and fertilizers, increasing pollution in the Tana River.

In short, the Tana River receives inadequate protection despite providing water and livelihoods to millions of people, 95% of Nairobi's water, and 50% of Kenya's hydropower supply. The watershed's potential to continue providing water and other vital ecosystem services is declining rapidly. Yet local residents who farm the upper watershed receive no outside investment or incentives to protect this critical resource by implementing measures that can ensure it provides abundant, safe water for everyone. If significant investments are not made to protect and improve land and water management in the Upper Tana, the river will become increasingly choked by sediments and pollutants, as well as provide less water. All these impacts will exacerbate declining productivity of farmland, water supplies, and water quality, while increasing the costs of water distribution and energy production for everyone in the Upper Tana and downstream. At the same time, the unique biodiversity that depends on a healthy Tana River will continue to be lost.

Water Security and the Upper Tana-Nairobi Water Fund

Given all the challenges the Tana River watershed faces, the Upper Tana-Nairobi Water Fund is one of Kenya's best, most cost-effective opportunities to protect these vital water supplies for millions of people, improve the livelihoods of more than 300,000 smallholder farmers, ensure sustainable production of hydroelectric power, and protect the Tana River's rich biodiversity.

³ WRMA 2011. Physiographical baseline survey for the Upper Tana catchment: Erosion and sediment yield assessment.

⁴ KenGen 2010. Annual report and financial statements.

Why a Water Fund and How Does It Work?



Healthy, functioning watersheds that maintain ecological services have been shown to reduce water treatment costs and improve water regulation for people who rely on the watershed. Further, investment in *green infrastructure* using natural systems to trap sediment and regulate water often provide a more cost-effective approach than relying solely on *grey infrastructure*, such as reservoirs and treatment systems. Water funds are a cost-effective way for downstream water users to invest in green infrastructure that will maintain sustainable water supplies from the watershed they depend on. Water funds usually involve public-private partnership (PPP) and a financing mechanism to invest in watershed conservation. The watershed conservation measures are strategically designed to protect the quality or quantity of water available for communities and the environment. Thus, a water fund unites public and private downstream users (e.g., water utilities and major private users), upstream watershed stewards (e.g., agricultural landholders), and other interested stakeholders (e.g., development organizations) to participate in and contribute to the fund, given their shared stake in a healthy water future.

Financial support of the water fund is used to promote sustainable land and water management practices upstream that filter and regulate water supply. These management practices can include strategically sited tree planting and land terracing, natural water holding features, and on-farm soil and water management practices. Funding is also used to support economic opportunities that enhance livelihoods and the quality of life for upstream communities that further incentivize farmers and landowners to implement sustainable management practices.

Indeed, many of the interventions that improve water quality and quantity also lead to increased agricultural yields. A water fund can also enhance communities' ability to adapt to climate change, by building in resilience to fluctuating water supplies and temperatures.

Implementation of water funds is a proven model founded on the principle that *it is less expensive to prevent water problems at the source than it is to address them further downstream*. For every dollar invested in conservation strategies in the Upper Tana River watershed, it is estimated that downstream stakeholder's dependent on the water will avoid two dollars in costs of correcting impacts on water supply and energy production. The trust provides a secure and transparent program through which public and private investors who depend on clean water supplies from the Upper Tana watershed can direct resources to conservation strategies that will yield the greatest returns for the common good and the economy.

Upper Tana-Nairobi Water Fund Mission and History

The Upper Tana-Nairobi Water Fund Trust was established in October 2015 and incorporated in October 2017 as a charitable Trust in Kenya. Its vision is to achieve a well-conserved and managed Upper Tana watershed that sustains healthy livelihoods and ecosystem functions in the region. To help achieve this vision, the mission of the trust is to secure the long-term conservation, protection, and maintenance of the Upper Tana watershed by advancing nature-based solutions to water security. The trust was the first water fund of its kind in Africa, built on experience TNC had gained from designing more than 40 water funds around the world. The trust was founded by three main partners — TNC, the NCWSC, and Pentair Inc. — in order to support long-term conservation, protection and maintenance of the Upper Tana watershed and thereby improve local livelihoods, Nairobi's water security, and Kenya's renewable energy supply. The trust has adopted a PPP model working collaboratively throughout the Upper Tana watershed on solutions to one of the greatest challenges to Kenya's future: source water protection. The trust is working to secure water for more than 6 million people in the city and an additional 5 million who live within the watershed area.⁵ The primary focus of the trust is to incentivize and increase adoption of farming practices that significantly improve water supply reliability and quality, and long-term watershed resilience. In doing this work, the trust operates based on five key values: integrity, partnership, accountability, commitment to nature, and empowerment. Together, living and working by these values, the trust will ensure that the work it does achieves the vision with transparency, equity, and collaboration.

⁵ 2019 Kenya Population and Housing Census. Volume 1.

Vision
A well conserved and managed Upper Tana watershed that sustains healthy livelihoods and ecosystem functions in the region and beyond.

Mission
To secure the long-term conservation, protection and maintenance of the Upper Tana watershed and the benefits it provides for people and nature by advancing nature-based solutions to water security.

Values - I-PACE

1. Integrity
2. Partnership
3. Accountability
4. Commitment to nature
5. Empowerment

The Business Case for the trust

The trust's creation followed a study assessing the economic and biophysical viability of a water fund for the Upper Tana River basin. The study, commissioned by TNC, NCWSC, KenGen, Pentair, International Centre for Tropical Agriculture, Tana and Athi Rivers Development Trust, Water Resources Authority (WRA), East Africa Breweries, Coca-Cola, and Frigoken Limited, evaluated the potential for widespread adoption of management interventions to reduce suspended sediment in waterways and increase dry season water flows in three priority watersheds (Sagana-Gura, Maragua, and Thika-Chania). These sub watersheds were selected because previous studies highlighted them as critical areas for improving water quality and quantity in the basin. The analysis used state-of-the-art land use planning and watershed modeling tools to quantify the benefits that would arise from a \$10 million investment in spatially targeted implementation of six interventions over a 10 years. The six interventions assessed were:

1. Vegetation buffer zones along riverbanks
2. Agroforestry along riverbanks
3. Terracing of steep and very steep farmlands
4. Reforestation for degraded lands
5. Grass buffer strips in farmlands
6. Mitigation of erosion from dirt roads

The annual impact of these interventions was evaluated both in terms of change in water supply and quality, as well as the economic impact for three key stakeholders: farmers in the watershed, NCWSC, and KenGen. This study concluded that over a 30 years, the benefits of strategically implementing the six management interventions at scale across all three watersheds over 10 years would result in reducing sediment concentration in the river by half, including a 20%

reduction in sedimentation in Masinga reservoir, and increasing water supplies during the dry season by 15% (Figure 4)

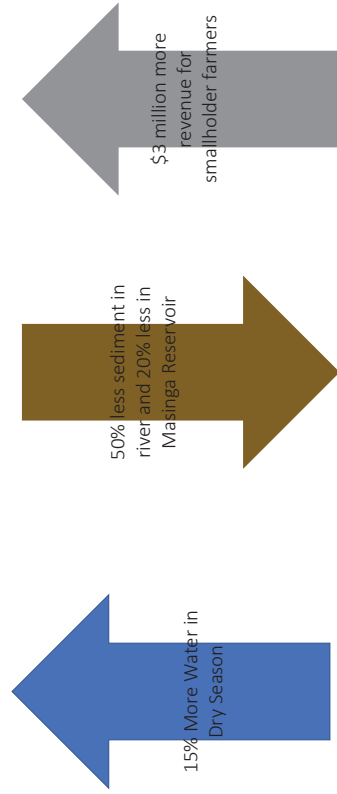


Figure 4: Predicted benefits of a \$10 million investment in best land and water management practices in the Upper Tana watershed over 30 years.

The study also found that these water benefits would lead to significant economic benefits for farmers, NCWSC, KenGen and their customers. These benefits would include more clean water for half a million people; \$3 million more revenue for farmers from increased crop yields; over 40 million m³ more water in Masinga Reservoir, leading to fewer power interruptions, enough new energy to support 2 million people, and \$600,000 more revenue from hydroelectric energy; and a reduction in annual water management costs of \$250,000 for NCWSC.

Overall, a \$10 million investment in the trust is expected to return nearly \$23 million in economic benefits over a 30-year time frame. In other words, for every \$1 invested, stakeholders in the basin will see over \$2 worth of benefits.

These calculated benefits are conservative and do not account for many other benefits that are difficult to quantify but highly valuable, including new employment opportunities, educational opportunities due to increased revenue for smallholder farmers, improved ecosystem services like pollination (worth about \$1 billion each year in Kenya), and improved air quality from planting over 100,000 new trees. There is also the possibility to see greater returns on the

investment if, for example, increased water yield results in greater energy production for KenGen.

Trust Progress 2015–2020

The trust has been under implementation for five years, during which time the main focus has been establishing partnerships and trust with Upper Tana communities and local leaders, building knowledge sharing systems, and engaging the Upper Tana communities to implement practices. Trust management staff also are working closely with county and regional representatives, as well as other partners (NCWSC, WRA, and the National Environment Management Association), to share information and advance campaigns for policy reform and to generate government support. As a result, the trust has established robust partnerships with four counties (Nyeri, Murang'a, Nyandarua, and Laikipia) in the Upper Tana River Basin. Those counties have committed to expand trust's impact by making additional investments in watershed management. Also, partnerships have been established with three local NGOs in the three priority sub watersheds of Thika-Chania, Maragua, and Sagana-Gura, including the International Centre for Research in Agroforestry (ICRAF), National Museums of Kenya, and Jomo Kenyatta University of Agriculture and Technology (JKUAT), which have been providing technical support to scientific baseline studies and impact monitoring.

Over the last five years, the trust has been using these partnerships and growing financial investments to work directly with farmers and volunteers to implement the sustainable land management (SLM) interventions listed above, as well as to install water pans that collect water during the wet season and reduce river diversions. Trust has also been working with local communities to install biogas units as a sustainable energy source. At the same time, the trust has improved existing and built new knowledge management and learning systems, including installation of 33 new automated river gauging stations and enrollment of 45,000 farmers in a mobile data monitoring program. These investments working with farmers in the watershed have already yielded significant benefits and set the stage for rapid growth and much greater impact over the next five years.

In its first five years, trust has exceeded expectations, leading to significant improvements in watershed management and local livelihoods (Figure 5). To date, trust has directly benefited over 200,000 farmers and is working with more than 44,725 farmers who are applying soil and water conservation practices (see Success Stories below). These improvements in management have helped 8,500 coffee farmers achieve Rainforest Alliance certification, thus increasing the value of their crop. The trust is on track to be working with 70,000 farmers by 2026. Further, 15,131 water collecting pans have been installed that collectively harvest over 900 million liters of water every year. Approximately 73,000 hectares of land in the watershed are now under improved, more sustainable management, including 36,000 hectares of public forest. Also, trust and partners in the watershed have already planted over 3 million trees in the last five years, which will lead to sequestering over 5 tons of carbon (CO₂e) per hectare over the next 30 years.

All of this progress toward more sustainable management of the watershed is yielding the water supply and quality benefits envisaged.

The trust actively collects a variety of biophysical data to measure its impact on water quality and quantity, including data on streamflow, turbidity, and total suspended solids (TSS). These data, taken together and analyzed, have been collected primarily in three main subbasins: Sagana-Gura, Thika-Chania, and Maragua. The results over the last seven years, comparing water quality and quantity before and after trust interventions, provide strong evidence that trust interventions are working as promised and improving watershed health by reducing turbidity and contributing to sustained baseflow in the rivers ([Appendix 2](#)). This is evident in that turbidity in the river has remained stable or even decreased during high river flows after interventions in targeted watersheds. As much as 55 million more liters of water are now reaching Nairobi's water supply reservoirs every day with an 11% reduction in turbidity. Also, baseflows in the rivers where best management practices have been implemented are either remaining stable or increasing despite growing water demands in the watershed.

In addition to these tangible physical results on the ground, trust is providing local farmers with new skills, training, and resources to improve the productivity of their land. UTNWF has deliberately sought to engage women and youth in its programs to increase their involvement and empowerment. So far, over 39% of women in the watershed are participating in sustainability programs, along with over 17% of youth (over the 10% national average⁶). These engagements have led to improved livelihoods and incomes of households, improved biodiversity, and enhanced ecosystems services for women-led households, youth, and people living with disabilities.

⁶ Kenya Youth Agribusiness Strategy, 2018–2022.

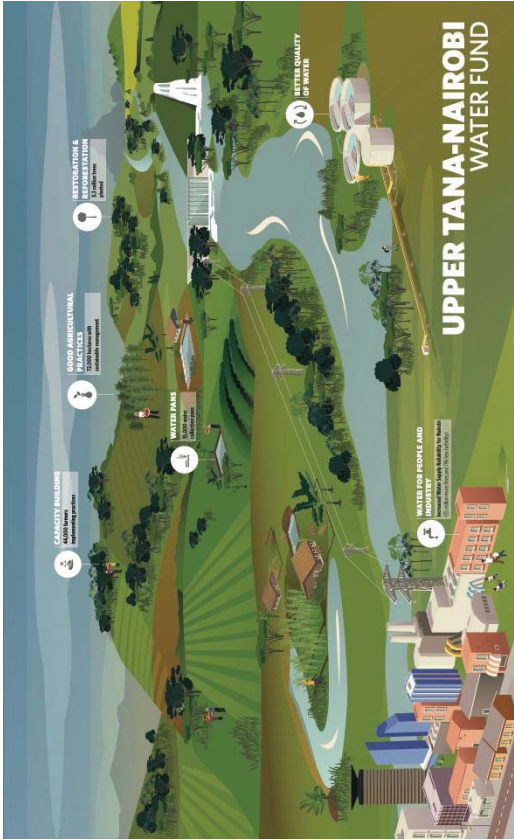


Figure 5: Watershed-scale results from the first five years of the Upper Tana-Nairobi Water Fund.

This progress has been made possible by a growing, dedicated staff of five full-time and 30 part-time extension coordinators working directly with communities to educate farmers about practices and help them implement best management with the investments made by trust. Long-term success will now depend on both scaling up implementation and having effective monitoring systems in place to measure water supply benefits being created.

This impact has occurred with 20% of the targeted \$10 million total investment. The goal is to fully fund the endowment by the end of 2022.

“We have grown the trust to an organization that delivers tangible results for people and nature. This water fund is well on its way to becoming the first financially sustainable water conservation initiative in Africa. Continued investment by stakeholders in the endowment fund to grow it from the current \$2 million to the targeted \$7.5 million will safeguard our water source and ensure its sustainability for the benefit of all.”

— EDDY NJOROGE, President, International Organization for Standardization and President and Trustee, Upper Tana-Nairobi Water Fund Trust

Purpose of this Revised Strategic Plan

The plan of the trust is to become fully established and staffed as an independent entity, separate from TNC, beginning in September 2021. This new strategic plan provides the road map for that

transition and for dramatically scaling the impact of the trust on water supplies, livelihoods, and the health of the Tana River watershed over the next five years. A successful transition and increased impact will require the continued dedication of the trust Steering Committee, the participation of NGO and community groups, and the support of the Kenyan government. While TNC, steering committee members, and other donors — including the Global Environment Facility, the Swedish International Development Agency, and Coca-Cola’s Replenish Africa Initiative — have provided funding to date, the trust’s success as an independent entity will depend on expanding public and private financial support. Support is needed from major Nairobi water users who recognize the business case behind this effort, as well as from generous donors interested in backing an innovative approach to development, climate change adaptation, and conservation.

The objectives of this five-year plan are to:

1. **Create Clarity:** Establish a framework for documenting and evolving important strategic choices made by water fund leadership.
2. **Provide Focus:** Allow for more effective goal setting and purpose-based leadership by the water fund.
3. **Chart a Shared Road Map:** Drive measurable progress toward impact and systemic change.

BOX: Success Stories

Irene Wanjiru Mumiria and her husband, James, own a farm that is their only source of livelihood. They depended on rain-fed subsistence agriculture. This was a challenge because of unpredictable and poorly distributed rains, as well as low market prices for their produce, as every farmer in the market sold the same crop. In 2017, the trust trained her on rainwater harvesting, agroforestry, and drip irrigation. Irene and James repaired existing soil conservation structures on their farm and planted high-value fruit trees along the contours. She excavated a 100,000-liter water pan and, by irrigating her crops, was able to grow high-value vegetables for the local market and for their household needs. In 2018, Irene bought two dairy goats worth Ksh 20,000, and in 2019, she installed a biogas unit from her farming income that now meets all her cooking and heating needs. These interventions have released time for Irene, and she is now able to join other women's activities and enjoy leisure time. The water pan on her farm has made it possible to harvest some food with unreliable rain in 2021. Irene and James can now fully pay for their two sons' secondary school education. Irene invests in shares worth Ksh 2,000 monthly from her banking group as part of a saving strategy for her family's future.



Peter Marubu was born deaf and mute and had nobody to help till the six-acre piece of land he inherited. He planted bananas, maize, and beans; reared two cows for subsistence on half an acre; relied on casual labor for income?; and leased the remaining five acres to other farmers. In 2018, trust staff taught him to build terraces on his farm and harvest water for irrigation, and his nephew helped him install a water pan to harvest rainwater from his roof. He took back his land and planted tomatoes, capsicum, watermelon, maize, and spinach. The sales from his capsicum and tomato harvest made him a total of Ksh 27,200. He installed a 10-horsepower pump to complement his new drip irrigation system, and in 2019, harvests from vegetables, tomatoes, and bananas made him Ksh 110,000. Peter has invested Ksh 10,000 to construct a zero-grazing unit for his dairy cows, and in 2020, he completed building a two-room stone house to replace his mud-walled house.



In 2021, Peter completed over 75% of recommendations on his farm-specific action plan. He has further prepared over 46 pits to plant plantain bananas, which have a high demand in the region. Currently, he can feed himself and maintain a healthy life from his farm proceeds. He is generating Ksh 40,000 from his banana plantation only. Before the water fund, he relied on income earned from casual labor.

Gladys Wangechi Migwi owns a four-acre farm and is one of the 8,500 farmers who are now Rainforest Alliance certified and selling their coffee at a premium. Using trust's technical advice, she built terraces and planted Napier grass to stabilize the soil on her farm. The Napier grass was used to feed her cows better and resulted in an increase in milk production from 10 to 14 liters a cow per day. She also planted more coffee trees, increasing them from 250 to 450, and the harvest grew from 3 kg to 10 kg per tree. She established a tree nursery from which she sells seedlings to her fellow farmers. She excavated a 100,000-liter water pan that enabled her to start



an organic vegetable garden, which has improved her family's nutrition and whose excess produce fetches her Ksh 800 to 1,000 every week at the market. Gladys runs a poultry farm and sells the eggs, while the droppings from her fowl are used for fish farming in a pond and as fertilizer for her vegetable garden. The dung from her two cows and 18 pigs feeds her biogas unit, while the bio-slurry is used as manure for her coffee trees. She runs a fully integrated farm enterprise, and her conservation efforts earned her an award for Best Overall Woman in Agriculture at a national competition held in 2017 by the Ministry of Agriculture.

Obstacles and Opportunities for Success of the trust

Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis

Despite the significant success the trust has had so far in its first five years, the watershed continues to experience significant challenges and many social and institutional barriers exist to realize the vision of a well conserved and managed Tana River watershed with improved livelihoods, healthier human and natural communities, and greater resilience to climate change. Generally, the key challenge that remains is the fact that water demands in the Upper Tana continue to rise with a growing number of diversions, leading to increasingly scarce surface water supplies. This problem is made worse by the significant soil erosion coming from many farms not enrolled in trust programs, along with encroachment on riparian zones and water quality degradation due to pollution from domestic or industrial sources. Also, river flows, especially dry season flows, that are intimately linked to groundwater levels are being further impacted by increased use of groundwater wells and decreased groundwater replenishment in the watershed overall. Groundwater and surface water are being used and managed independently without any watershed-level integrated management to ensure both are being used sustainably.

In formulating this strategic plan to ensure that trust can build from its success and be well prepared to address key barriers to achieving its mission, an assessment was conducted of both internal and external operating environments. Specifically, the trust assessed its existing strengths and weaknesses, as well as the external opportunities and threats that will enable or hinder progress in the watershed. In implementing this strategic plan over the next five years, the trust will use this assessment to enhance its internal strengths and capitalize on the most important opportunities while also addressing identified weaknesses in its operations and mitigating those factors that pose a threat to achieving success. A summary of this assessment is provided in [Appendix 3](#).

Critical Issues and Priorities

Based on this assessment, there are three critical priorities vital to the trust's success with this strategic plan:

- 1) **Partnership.** Active participation by county governments and local communities will be essential for implementing and scaling nature-based solutions in the Upper Tana watershed. Fortunately, the trust has strong relationships with devolved governments that have committed to helping fund the trust's work; with community-based organizations (CBOs); and with a well-developed network of community volunteers. Critical challenges that remain include maintaining effective partnerships with local governments, insufficient communication about the trust's work and impact, and capacity to engage national and regional leaders for influencing relevant legislation. To address these issues, the trust over the next five years will prioritize the following activities to increase effective partnerships:
 - a. Increasing coordination with county governments and other regional groups to improve communication and increase the level of regular collaboration; mitigate

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the impacts of high staff turnover in county government; and reduce impacts of incompatible legislation or lack of local enforcement.

- b. Increasing the trust's capacity to implement marketing strategies highlighting the benefits of its work, partnerships, and impact in order to raise trust levels of commitment from internal and external partners.
- c. Improving the trust's capacity to engage regional and national decision-makers and investors so that trust can have greater influence on supportive legislation and inspire multiple levels of government to invest in upper watershed management.

2) **Science and innovation.** Key to trust's success will be using innovation and science-based decision-making in its planning and management. The trust has helped build a more robust monitoring network that includes local volunteers and a network of remote river monitoring stations. However, environmental data being collected regularly in the watershed remains too inadequate to prioritize interventions and measure impact over time. Also, the trust and its local partners do not yet have enough staff or technical capacity to deploy monitoring systems or collect and analyze data regularly. To address these problems, the trust over the next five years will prioritize:

- a. Modernizing and digitizing environmental data collection networks and information management systems for the watershed.
- b. Recruiting, retaining, and motivating qualified, professional staff both internally and externally.
- c. Increasing internal and external staff capacity to deploy monitoring systems and analyze data to guide investments so that they have the greatest environmental and social return on investment.

3) **Financial Resources.** Without adequate financial resources, the trust will not be able to adequately resolve the critical issues described above or sustain and expand the implementation programs developed over the last five years. The trust's goal is to secure and invest \$10 million into the watershed over the next five years. This will include an approximately \$1 million annual operating budget for the trust and \$1 million per year in direct implementation. To achieve this, the trust over the next five years will prioritize the following:

- a. Improving understanding of the link between environmental conditions in the Upper Tana and the needs of downstream water users.
- b. Developing and executing a fundraising campaign to secure the partnerships and financial resources needed to significantly improve environmental and social well-being in the watershed.
- c. Implementing and documenting the benefits of high-impact interventions in the watershed and use these projects to inspire new and bigger investments in the watershed.

The key risks and critical issues will evolve over time as some are resolved and others arise. However, over the next five years, the critical issues above will be the trust's priority focus. Any

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other risks or critical issues that arise over the next five years will be prioritized and addressed as necessary.

Trust 2022–2026 Objectives and Strategies

Objectives

The trust is advancing a holistic approach to supporting the long-term conservation, protection, and maintenance of the Upper Tana watershed in order to protect the environment in ways that improve the lives of thousands of smallholder farmers, improve Nairobi's water security, and ensure optimal functioning of hydropower facilities along the Tana River. This will be achieved by deploying practical conservation measures in the Upper Tana that improve livelihoods through greater water security and income, while also ensuring that downstream water users reap the benefits of their investments for water security in the upper watershed. With this holistic view in mind, the trust over the next five years will focus on increasing its credibility and reputation as a leader and partner with regional and local stakeholders, applying the best available science and technology to ensure the greatest environmental and social return on investments, and securing the resources (both financial and social) to ensure the long-term sustainability of the trust and its partnerships.

The goal of the trust over the next five years and beyond is to improve water quality and quantity in the Upper Tana watershed for downstream users, enhance food security, protect freshwater and terrestrial biodiversity, and improve human well-being of local communities.

The trust has identified four strategic objectives toward these goals:

Objective 1: Enhance the Upper Tana's Resilience Climate Change to Protect its Biodiversity and Ecosystem Functions. This objective includes improving ecosystem conservation; restoring forests, riparian zones, and wetlands; and conserving soil and water.

Objective 2: Improve Socioeconomic Conditions for Local and Regional Communities Through Improved Land Management and Economic Opportunities. This objective includes improving the supply and quality of water, creating higher value and sustainable supply chains for agricultural produce of the region, contributing to economic development and poverty reduction, increasing food security, and empowering youth.

Objective 3: Protect and Increase Water Supply and Quality with Enhanced Resilience to Climate Change. This objective will include reducing overall sedimentation in the river, increasing average water yield, and increasing dry season flows.

Objective 4: Secure and Establish Effective Policies, Knowledge Management Systems, and Funding to Sustain the Water and Land Conservation Activities in the Upper Tana. Achieving this objective will include increasing the capacity and accountability of trust stakeholders; establishing robust data collection and sharing systems as part of monitoring, evaluation, and

adaptive management; improving policies and investments of local governments and partners; strengthening trust institutional capacity; and securing an operating endowment that can sustain the work of the trust indefinitely.

Strategies

To achieve the objectives above, the trust will invest in four core strategies focused on addressing the critical issues identified above and on demonstrating and scaling its impact over time. These strategies are:

- 1. Demonstrate Effective Integrated Natural Resources Management** in the Upper Tana watershed by working closely with communities to implement and measure the impact of an integrated suite of interventions that protect and improve water supplies. This will include protecting intact riparian forest and wetlands, water harvesting, conserving and efficiently managing soil and water, and improving quarry management and reclamation.
- 2. Increase Watershed Capacity to Improve Livelihoods, Food Security, and Economic Development** in the Upper Tana by developing value chains for niche agricultural produce, improving rural road shoulders with low-profile vegetation cover to prevent soil erosion, creating smallholder food security initiatives, automating climate and weather advisories with early warning systems, providing effective land use planning, and empowering the entire community.
- 3. Build a Robust Knowledge Management and Learning System** to strengthen accountability, stimulate learning, improve program performance, and facilitate better organizational decision-making. This will require increasing internal and external capacity through training and mentoring, building larger, more robust data collection and analysis systems, and improving reporting about watershed conditions and the social and environmental impacts of trust programs.
- 4. Enhance Financial Sustainability and Institutional Capacity of the Trust** by increasing donations and growing the endowment fund; creating and implementing plans for staff recruitment, training, and retention; implementing the successful transition to an independent fund; and finalizing trust standard operating procedures for financial accounting, staffing, contracting, and partnerships.

Implementation/Action Plan

A diverse and interrelated suite of activities has been identified to implement the strategies above. These activities are intended to be measurable and specific as well as to directly contribute to meeting the ultimate objectives of the trust. Some of these activities are external and, to be successful, depend on the close partnerships with stakeholders. Others are more internal and associated with managing the trust as a well-functioning, accountable, and transparent organization. All these activities depend on acquiring the resources needed to make

direct and indirect investments within the watershed. To achieve the set objectives, Table 2 provides the activity outputs and outcomes indicators.

Table 1: Indicators of success for trust priority objectives.

Objectives	Output Indicators	Outcomes
Objective 1: Enhance the Upper Tana's Resilience Climate Change to Protect its Biodiversity and Ecosystem Functions	1. 100,000 hectares of natural lands and agroecosystems managed under sustainable land and water management best practices.	1. Sustainably managed lands in Upper Tana catchment.
	2. Relative abundance and composition of intolerant macroinvertebrates (BCG Attribute 2) for sites in treatment micro watersheds with BCG scores >3 increased compared with 2021 baseline data.	2. % of households with increased permanent vegetation cover. 3. Increased dry period water flows in Upper Tana. 4. Acreage of forest under improved management. 5. Tons of greenhouse gas avoided or sequestered. Abundance and composition of intolerant macroinvertebrates for sites in treatment micro watersheds.
	3. 70% of smallholder farmers report increased productivity as a result of the implementation and adoption of climate smart SLM practices, compared with the 2021 baseline, by 2026.	6. Smallholder agricultural productivity improved by 30% by June 2026. 7. Improvement in water quality and quantity for downstream water users by 2026 compared with 2016 baseline.
Objective 2: Improve Socioeconomic Conditions for Local and Regional Communities Through Improved Land Management and Economic Opportunities	4. 70% of smallholder farmers report increased incomes through the implementation and adoption of climate smart SLM practices, compared with 2021 baseline, by 2026.	8. The number of polymers used for treating water per m ³ for the Nairobi water supply reduced by 10% by June 2026.
	5. Number of installed and operational water monitoring stations in the watershed. 6. Number of km of riparian land protected. 7. Number of water pans and drip irrigation systems installed. 8. Number of acres under improved management.	9. Average total suspended sediments and the turbidity of the Upper Tana rivers are reduced by 15% compared with the 2016 baseline data. 10. Mean annual water yield in the Upper Tana rivers increased by at least 15% compared with the baseline annual averages of 2016. 11. Dry season flows of the Upper Tana rivers in the micro watersheds increased by 15% as compared with baseline in 2016. 12. Annual average amount of polymers used to treat a unit volume of raw water decreased by 10% compared with the 2015 baseline. 13. Number of hours for which turbidity at Mwagu intake is more than 200 NTU reduced by 10% compared with 2015 baseline.
Objective 3: Protect and Increase Water Supply and Quality with Enhanced Resilience to Climate Change		

Objective 4: Secure and Establish Effective Policies, Knowledge Management Systems, and Funding to Sustain the Water and Land Conservation Activities in the Upper Tana	9. Water fund is fully transitioned to a separate entity by September 2021. 10. Knowledge sharing done with at least two other water towers by 2026. 11. \$7.5 million invested in an endowment account, generating \$750,000 annually for operations and conservation investments. 12. Four county governments within the trust priority watersheds have at least four new conservation-based operational policies in place. 13. Clear annual reports on activities, budget, and outcomes are publicly available. Operating and compliance manuals completed. Annual meetings with BoM and BoT have taken place. 14. Number of coordinated national and local strategies and policies in watershed have taken place.	14. Other sites or water funds benefit from the water fund's learning and improved knowledge by 2026. 15. National and local partners have improved capacity to adaptively manage watersheds by 2026. 16. Water fund leadership transparency and accountability is sustained.
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Road Map

To increase accountability, track progress, and inspire staff as well as partners to achieve the trust's important objectives, the trust has set specific and tangible measures of progress based on the priority activities that should lead to the achievement of the fund's five-year objectives. These metrics of success will be the standard by which trust measures its progress over the next five years and to which staff will be held accountable. Each year, there will be an evaluation of progress, and adjustments will be made to strategies and activities as needed to direct the fund's resources to the most important aspects of its work and to ensure that investors' contributions are used wisely. **Error! Reference source not found.** Table 2 lists the priority activities that the trust will dedicate its time to over the next five years to achieve the objectives above.

Table 2: Five-year road map of outputs for all priority activities.

Objectives	Strategy	Activity	Indicator	Target	Year 1	Year 2	Year 3	Year 4	Year 5
Enhance the Upper Tana's Climate Resilience Change to Biodiversity and Ecosystem Functions	Demonstrate Effective Integrated Natural Resources Management	Promote and implement terracing on steeply sloped cropland	# Meters excavated	500,000	30,000	50,000	120,000	200,000	100,000
		Promote and implement grass strips on flat and gently sloping farms	# Meters planted	500,000	30,000	50,000	120,000	200,000	100,000
		Promote and implement vegetation buffer zones along riverbanks and with grass buffer strips in farmlands	# Meters planted	50,000	5,000	10,000	15,000	15,000	5,000
		Promote and implement agroforestry practices	# of seedlings planted	20,000	2,000	4,000	5,000	6,000	3,000
		Promote rainwater harvesting through installation of water pans	# of water pans installed	5,000	500	2,000	2,000	300	200
		Promote efficient water use through drip irrigation	# of drip kits installed	300	50	100	100	30	20
		Promote biogas for efficient energy use	# of units installed	100	20	20	20	20	20
		Ensure that smallholder households implement at least two sustainable land management best practices or technology	# of households with >1 SLM	20,000	5,000	5,000	4,000	3,000	3,000

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Objectives	Strategy	Activity	Indicator	Target	Year 1	Year 2	Year 3	Year 4	Year 5
Improve Socioeconomic Conditions for Local and Regional Communities Through Improved Land Management and Economic Opportunities	Build Robust Knowledge community-based data and information sharing platform for the Trust	Support farmers groups in attaining appropriate certification	# of certified groups	5	1	1	1	1	1
		Support farmers groups in attaining appropriate certification	# of value chains supported	3	-	1	1	1	-
		Provide technical agricultural support and services to smallholder farmers	# of farmers reached	70,000	10,000	20,000	20,000	15,000	5,000
		Finalize a monitoring and evaluation framework, and establish capacity through partnerships to implement robust annual monitoring and analyze and communicate results	# Plan and partnerships		Finalized M&E plan	Monitoring partner-ships established			
		Establish a digital and community-based data and information sharing platform for the Trust	# digital and community systems established		Digital systems developed	Community data sharing framework created			
		Share data and lessons learned from implementation with partners, stakeholders, and events held	# of reports, meetings, and events held	20	3	4	4	4	5
		Monitor water quality and quantity	# of campaigns conducted	20	4	4	4	4	4

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Objectives	Strategy	Activity	Indicator	Target	Year 1	Year 2	Year 3	Year 4	Year 5
Secure and Establish Effective Policies, Knowledge Management Systems, and Funding to Sustain the Water and		Download data and maintain river gauging stations	# of Monthly data downloads	60	12	12	12	12	12
		Field monitoring visits	# of field visits	20	4	4	4	4	4
		Share data, lessons, and experiences of the water fund with partners, stakeholders, and other watersheds in Kenya	# of workshops held	20	3	4	4	4	5
		Build, calibrate, and validate the Biological Condition Gradient (BCG) model and use it to inform land and water resources conservation	BCG model calibrated and validated				Completed model		
		Install automated climate and weather advisories systems to disseminate information on weather patterns to farmers	Climate and weather advisory system installed		System installed				
	Enhance Financial Sustainability	Assemble, train, and effectively manage a trust team capable of achieving objectives	# of trainings conducted	10	5	3	2	-	-
	Institutional Capacity of the Trust	Develop and implement fundraising plan	# of Plans developed and fundraising events or meetings	Completed 40 events	15	10	5	5	5

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Objectives	Strategy	Activity	Indicator	Target	Year 1	Year 2	Year 3	Year 4	Year 5
Land Conservation Activities in the Upper Tana		Raise at least \$7.5 million, generating \$750,000 annually.	US\$ raised	\$7.5 million	\$1.52 million	\$1.52 million	\$1.52 million	\$1.32 million	\$1.32 million
		Participate in county, national, and international forums to inform and influence policy decisions on natural resources management	# of meetings attended	10	2	3	3	1	1
		Coordinate national and local strategies and policies in the watershed and catchment	# of policies/strategies adopted	5		2	2	1	

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Monitoring and evaluation (M&E) is critical for the sustainability and impact of a water fund. If the trust fails to systematically and rigorously demonstrate the benefits of nature-based watershed management, it risks losing its political, social, and financial support and, ultimately, to achieve its vision for the Upper Tana watershed. At the core, trust's M&E trust will focus on tracking achievement based on key performance indicators (output and outcome indicators) related to the ultimate objectives and what can be reliably reported to stakeholders.

The project's theory of change drives the selection of output and outcome indicators. Output indicators measure project implementation progress, while outcome indicators are results that are necessary to achieve the intended impact of the water fund. The project has 14 output indicators and 17 outcome indicators covering ecological, social, and economic focal areas (Table 1).

In addition to enabling the trust to measure its progress and remain accountable to its objectives for stakeholders, the data collected will also be an important way for the trust and its partners to inform local communities, investors, and government. To share progress and knowledge over time, the trust will establish a knowledge center, complete annual reports on performance indicator changes, engage in school awareness programs and peer-learning groups, and present the trust's work and results at workshops and seminars.

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The flowchart illustrates the implementation of the Watershed Resilience Strategy (WRS) in the Upper Tanu, A. It is organized into columns representing different stages: Co-benefits, Goal, Outcomes, Intermediate Results, Strategies, and Problems. The flowchart details the progression from initial problems through various strategies to intermediate results and finally to outcomes and co-benefits.

Problems:

- Inadequate resources and capacity to sustainably carry out conservation work
- Inadequate policies on watershed management and capacity to measure changes
- Poor agricultural yields, food insecurity and vulnerability to climate extremes
- Reduced dry seasons river flows
- High river sediment loads in waterbodies during wet season

Strategies:

- Enhance financial sustainability and institutional capacity of the trust
- Build a robust knowledge management and learning system
- Increase watershed capacity to improve livelihoods, food security and economic development
- Establish effective integrated natural resources management

Intermediate Results:

- By Sept 2026, resource mobilization strategy effected: 40 resource mobilization events held, 10 capacity enhancement training conducted
- By Sept 2026, 4 watershed management policies enacted at counties, 20 knowledge sharing seminars organized/participated in, a robust Mkt system established
- By Sept 2026, 20,000 RWH water pans and 300 drip kits installed, 5 groups receive relevant crop certification, 70,000 farmers receive technical agronomic support
- By Sept 2026, 70,000 smallholder farmers implementing SLM practices, 70 km of rural roads shoulders protected, 1000 km of grass strips and terraces implemented, 30,000 Ha of degraded forest rehabilitated

Outcomes:

- By Sept 2026, US\$ 7.5 million raised for sustainability of conservation work in the Upper Tanu, A, conservation management strategy established
- By Sept 2026, 4 counties implementing watershed management policies for effective management of water sources, stakeholders using the learning dashboard to make prior informed decisions, 2 other water funds benefiting from the lessons of the trust
- By Sept 2026, 70% of beneficiaries report increased productivity and crop yields, 30% increase in crop yields
- By Sept 2026, 100,000 hectares of lands under sustainable land and water best management practices, biodiversity (BG) improved to less than 3, Water quality (WQ) improved by 15%, GHG reduced by 10%

Goal:

- By Sept 2026, the watershed has improved water quality and quantity, food security, biodiversity and improved human well being of local communities

Co-benefits:

- By Sept 2026, 5 million people in the watershed have improved water quality and quantity supply
- By Sept 2026, local communities have greater access to food markets and influenced others to adopt sustainable management of lands
- By Sept 2026, institutions have increased capacity to measure watershed conservation impacts

Figure 6: Theory of change

The intermediate results in the theory of change are tied to a strategy that is supported by an output and outcome indicators that lead to the realization of the trust goal and objectives.

Assumptions underlying the theory of change

- A. If land and water resources are put under best management practices in the upper Tana watershed, water quality and quantity will be improved as well as record a vibrant biodiversity status.
- B. If land productivity and food production is improved, then incomes and food security at the household level will increase thus improving the human wellbeing of the communities.
- C. If watershed management policies are formulated and enacted, and stakeholders/partners have access to data and information, then there will be better and adaptive management of the watershed.
- D. If US\$ 7.5 million are capitalized in an endowment fund, there will be a guaranteed sustainability of activities implemented in the watershed in perpetuity.
- E. If 70,000 farmers implement at least one SLM measure and 30,000 Ha of degraded forest are under improved management, 100,000 Ha of forests and agroecosystems will be conserved leading to improved water quality and quantity by 15% and reduced GHG emissions.
- F. If farmers implement rainwater harvesting (RWH) technologies and efficient irrigation methods are used in the dry seasons, and the trust further offer agronomic support, then crop production will increase thus increase incomes from sale of farm produce.
- G. If the trust provides a platform for development and formulation of watershed conservation policies and engages stakeholders in knowledge sharing seminars and workshops, then at least four participating counties will adopt and implement the policies; and if the water fund knowledge and lessons learnt are shared widely, replication in other watersheds will be observed.
- H. If a robust resource mobilization strategy is established and at least 40 mobilization campaigns held, then the trust will raise US\$ 7.5 million endowment fund for sustainability of conservation activities in the watershed.

Five-Year Trust Budget

The trust has an annual operating budget of \$2 million. This figure includes all operational costs of the trust and needed direct investments in conservation actions within the watershed. Of this total \$10 million budget for five years, the trust anticipates a 1:1 matching investment from counties based on their previous investments over the last five years. Exact annual budget amounts will vary based on opportunities and the phasing of work overtime as the trust establishes itself as an independent organization and expands its programs. Given the existing endowment and funding commitments already secured and assuming the \$1 million matching investment per year from partners, the trust has a funding gap of approximately \$500,000 for the first two to three years, which will grow to approximately \$800,000 in the final two years of this strategic plan. A priority for the trust is to close this funding gap by raising \$3-5 million within

the first three years of this strategic plan, with a goal of securing some or all of this funding as an endowment to provide long-term operating funds for the trust.

Operational Plan

The trust has a governance structure that includes a board of trustees, a board of management, and six full-time staff led by an executive director (Figure 7). The Board of Trustees is responsible for setting the vision, mission, and policy directions. The trustees comprise the Board of Management, whose mandate is to oversee the overall implementation of the Trust's conservation programs, projects, and activities in a coordinated manner operating from the Trust's headquarters. Twelve full-time staff members, led by an executive director, develop and implement the strategies and day-to-day activities of the trust. Complementing the BoM and staff efforts is the Counties Advisory Committee. The CAC is responsible for advising trust staff and ensuring that county policies are addressed in trust operations, and for enabling implementation of strategies at the county level. The CAC also serves as close partners and co-funders of trust programs by aligning county programs with those of the trust and providing financial support.

The trust's work also depends on collaboration with other implementing partners, including Government of Kenya agencies, NGOs, CBOs, and the farmers who will be supported by technology promoters (TPs) and interns.

Additionally, the structure provides for other part-time positions for which staff will be engaged as and when required. These positions include retainer services (such as IT, communication, events/marketing, and human resources management and other human resource services), as well as outsourced services such as auditing, investments, tax advisory, training and fundraising. The Organogram is as displayed in Figure 7.

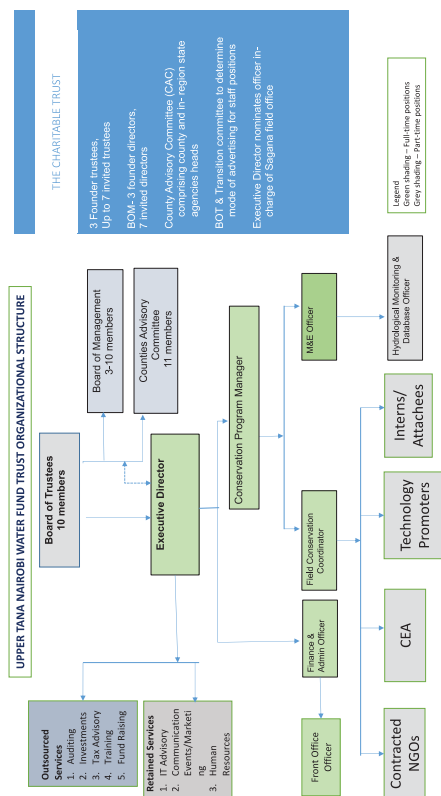


Figure 7: The Trust's organizational structure.

Communication Plan

The trust will require to communicate various aspects of its operations to partners, stakeholders and clients both internally and externally. This communication will basically involve communicating the progress in the implementation of the strategic plan and also creating awareness and education on the trust. In this regard therefore, the trust will adopt various methods of communication including but not limited to development of fliers and educational materials, workshops, seminars, webinars, participating in world days to mark various water and environment related celebrations under a defined communication plan.

The trust communication plan is as per the Table 3.

Table 3: Communication Plan for the Upper Tana Nairobi Water Fund Trust

Description	Frequency	Channel	Tools	Audience	Responsibility
Field activities implementation status	Weekly	Zoom/Teams	Weekly reports	CEAs, HMA, Conservation program staff	Field Conservation Coordinator
Program implementation status	Bi-weekly	Zoom/Teams	Biweekly reports and workplans	Trust staff	Program Manager
Focal Area Team meetings	Monthly	Zoom/Teams	Monthly report, workplans, success stories	CBOs, NGOs, implementing partners, counties, and Trust staff	Field Conservation Coordinator

Description	Frequency	Channel	Tools	Audience	Responsibility
Counties program updates and policy reviews	Quarterly	Zoom/ in-person meetings	Quarterly reports, PowerPoint slides, policy documents	County executive members, government agency heads, Trust staff	Field Conservation Coordinator
Program check-in meetings	Monthly	Zoom/ in-person meeting	Monthly progress reports, workplans	Trust staff	Executive director
Milestones and deliverable updates	Quarterly	In-person	Quarterly reports, Quarterly memos, Quarterly workplans, Success stories, blog articles	Trust staff, BOM	BOM and BOT chairpersons
Sharing project outcomes in national events	Annual	In-person/Zoom	Annual reports, flyers, brochures, PowerPoint slides, documentaries, success stories	All stakeholders, trust staff, CAC, BOM and BOT	Executive Director
Financial and program review	Annual	In-person/Zoom	Financial statements, annual progress report, annual workplan and budget, newspaper articles	BOT, BOM, project staff	BOT Chairperson

Appendix 9

Site Visit Upper Tana - Capacity Building (18th – 20th September 2023)

SITE VISIT UPPER TANA
CAPACITY BUILDING
18th -20th September 2023

1. Introduction

As Part of **Activity 1.2-** Survey on support activities by other development partners, JICA expert team collaborated with the Blue Deal (BD) in capacity Building of WRA staff in Embu Regional offices from 18th -20th September 2023. The team also took opportunity to elaborate activities on Hydrological Monitoring under Activity 3 and 4.

In Kenya, The Blue Deal (BD) program sets out to strengthen the three crucial elements of good water management: sufficient knowledge and expertise, a well-functioning organization and cooperation with key stakeholders. The Blue Deal programme is implementing the Upper Tana project with WRA as the local partner. The program is financed by the Dutch Ministry of Foreign Affairs and the Dutch Ministry of Infrastructure and Water (50%), Dutch Water Authorities (about 40%) and the local partner 10%. WRA is working with DWA to develop Water Allocation plans for Upper Thika and Middle Thika sub catchments, review Abstraction and Pollution Surveys, develop compliance and enforcement plans as well as have one showcase project (Common Intake) at a location within the project area. Various grassroots stakeholders are involved in the implementation of the project.

2. Overall Objectives

The JICA expert Advisor overall objectives is strengthening of WRA capacity on Hydrological Data Management related to data observation, arrangement, Storage and analysis.; Utilization of Observation results required for solutions to water resources-related issues such as flood, drought, and climate.

3. Site Visit Period: 18th -20th September 2023-Nairobi (18th), Embu (19th-20th)

4. **Participants;** Doreen Iluba; Eugene Mwandoe; Denis Masika; Gilbert Maiyo; Blue Deal Staff, Dutch water Authority (DWA) and Sub-region Staff.

5. Table of Itinerary-Workplan

Date	Schedule	Participants
Monday 18 September		
9.45 – 10:30	DWA Team meeting (NHIF building, 3 rd floor)	all
10:30 – 12:00 WRA HQ - boardroom	Combined meeting with JICA, WRA and DWA - Exploring collaboration on similar activities within tana basin (monitoring, KOBO app, WEAP, flood early warning).	DWA: Jeroen, Epke, Kendele WRA: Dr. Naomi, John Kinyanjui, Jared, & Gabriel JICA : Eugene, Gilbert & Dr. Masika -
10:30 – 12:00 WRA HQ – Water quality office.	Meeting with Water Quality team. - Updating WRA HQ about the work session in Embu and planned introduction of the RHA	DWA: Jacques, Kirsty, Jirome, Baxton WRA: Ombaka, Fred
12:00-14:00	lunch	
14:00-16:30 WRA HQ - boardroom	Workshop on Flood Early Warning - HQ - An evaluation based on the experiences so far, both in Nzoia and in Tana and Athi basins - Explore options that are available with respect to FFS components and software. Using examples from Japan and elsewhere. - Design strategy for any future FFS. A list of 'must haves' and 'should haves' will be part of this design strategy.	DWA: Jeroen, Epke, Kendele WRA: Ngesa, Gabriel JICA: Eugene
14:00-17:00	Catchment restoration discussion. - Meeting with JKUAT university staff to discuss the sedimentation study planned for Thika river. - Travel to Murang'a.	Jirome, Kirsty, Jacques, Simon, Baxton Dr. Benson - JKUAT

Date	Schedule	Participants
	Overnight stay in Murang'a - Nokras Murang'a Overnight stay in Nairobi Ndemi place	Jirome, Jacques, Kirsty, Simon, Baxton Epke, Jeroen, Kendele
Tuesday 19 September		
All day	Field work on the assessment of riparian conservation on sedimentation Begin in Murang'a WRA office by sharing plan for field exercise of sedimentation load sampling in Thika river. Implementing the field work with WRA staff and WRUAs (JKUAT).	Jirome, Kirsty, Jacques, Simon <i>Faith, Baxton</i> <i>Thika mid/upper WRUAs.</i>
08:00-10:00	Travel to Embu Office	Epke, Jeroen, Kendele
All day	Work session (monitoring stations) with Kendele	Jeroen & Kendele
	Discuss evaluation report. Preparing plan for the rehabilitation of monitoring stations. (What does it cost, who will do the rehabilitation, which stations to be rehabilitated)	Pauline Jane
10:00-17:00 (WRA Embu Office boardroom)	WEAP workshop in Embu town - - Bringing surface water officers from all sub-basins to introduce WEAP for water allocation planning. Present how the Thika-Chania model was developed and how it is used in the WAP. - Presentation by JICA how to use Mike Info for day-to-day water allocation. - Discussion of the benefits for using MIKE info in conjunction with WEAP.	Epke, Pauline , Jackline Gilbert, Eugene – JICA WRA surface water (Kerugoya, Garissa, Meru, Kitui, Murang'a)
Wednesday 20 September		
All day	Field work on the assessment of riparian conservation on sedimentation	DWA: Jirome, WRA: Baxton & Simon WRUAs
All day	Discussion on the mobile monitoring app. Exploring other mobile application for water level monitoring, customization and testing app.	DWA: Jeroen WRA: Jane, Kendele
10:00 – 12:00 (WRA Embu office boardroom)	WEAP results work session and implementation on WAP Status of WAP and following steps Using WEAP climate change scenarios in the WAP.	DWA: Epke, Murang'a – Faith and Embu – Pauline, Mbogori (water rights), Githu. JICA team
12:00 – 13:00 (WRA Embu office boardroom)	Water Quality Management work session get an overview of existing WQ monitoring, available data, present status of WQ in the Thika, existing interventions and projects.	DWA: Jacques, Kirsty, WRA: Jackline, Joram, Patricia Representative from FDB community biodiversity and Water Q & Q taskforces

Date	Schedule	Participants
14:00 – 16:30 (WRA Embu office boardroom)	Water Quality Management work session Making plan for continuous collaboration between WRA and DWA	DWA: Jacques, Kirsty, WRA: Jackline, Joram, Patricia Representative from FDB community biodiversity and Water Q & Q taskforces

6. Capacity Building Briefs

Activities carried out in collaboration with WRA Embu Regional Office and Muranga Sub-regional Office occasionally also Kerugoya Sub-regional office. The main activities carried out are surface water and water quality monitoring of key gauging stations in the Thika sub-catchment.

- To this end, the network has data loggers installed at key stations for data downloading by the BD project officer in collaboration with the sub-region
- Both the local BD Team and WRA officers conduct joint field activities i.e. surveys, surface water and water quality data acquisition with emphasis on sedimentation monitoring.
- The Team has hence established a database for the study area which has been used to develop a WEAP based model to inform preliminary prototype for a Water Allocation Plan to be used for WRA Capacity building and replication in the other sub-basins in Tana basin.
- A brief presentation of the WEAP Model application was discussed and updates of its application in collaboration with WRA Regional Surface Water Officer Madam Pauline
- Hydrological data collection has been enhanced by BD - WRA collaboration through installation of data loggers and frequent field monitoring of hydrometric stations in the study area.
- Blue Deal has plans to provide **20 No.** of Data Loggers to WRA for installation to improve on water resources monitoring in Tana basin thereby enhance quantifying water allocation using WEAP applications in the Sub-regions.
- Other activities BD is carrying out include Water quality and sediment monitoring in Thika Sub-basins.

7. JICA -WRA Team key submissions

JICA-WRA Team presented the ongoing activities and key study areas emphasizing that the tasks cover the entire Tana basin unlike BD.

- The meeting was presented with the main goal i.e. Strengthening WRA through monitoring and improving data assessment to enhance capacity in WRA on diverse aspects of WRM.
- In this regard, JICA-WRA Team plans to capacity build WRA Staff on hydrological analysis, data storage and information products generation for use in making informed decisions on water allocation at sub-basin level.
- That JICA-WRA Team also aims to provide advisory on matters concerning flood and drought mitigation. The meetings was informed that following discussions with WRA, flood and drought prone areas have been identified and is being studied with an aim of coming up with a framework for appropriate advisory on the same.

8. Embu WRA Regional Office 20th September, 2023

9. WRA/BD/JICA Capacity Building Presentations

10. WEAP Model Application

WEAP BD/WRA Team presented WEAP Model applications on Thika sub-basin.

The model was populated with hydrological and water demand data running on monthly time series and scenario assessment on baseline conditions with no abstractions representing natural conditions.

Another scenario presented was that of the current status representing status populated with current level of abstractions and demands.

A proto type Water Allocation Plan (WAP) based on the scenarios was also presented and the meeting informed that a document on the same had already been submitted to WRA Head office for possible implementation in the Thika sub-basin and replication in other sub-basins if accepted at that level.

11. Mike Suite Software Adapter for Linking WEAP Model

After WEAP presentation, JICA-WRA Team presented a methodology to link WEAP Model to Mike Zero Suite of modeling software using an Adapter developed under and applied in the larger Nile Basin Initiative (NBI) to which Kenya is a member and WRA the implementing institution for Kenya.

The Adapter provides a platform for linking other software such as WEAP, SWAT, ModFlow among others to take advantage of enhanced inbuilt analytical and decision support capability of Mike software tools. Some of the tools were demonstrated in the meeting for apprehension.

The meeting was informed that WRA being part of the NBI implementing institutions has the requisite licenses to use Mike Software and that the added value is that the software supports telemetric data transmission in real time as currently being implemented by WRA with the receiving base station at the head office. In this regard, the meeting resolved to follow-up the matter with the WRA head office for appropriate advice on the way forward.

12. Discussions

Following presentation of model results and simulations, the meeting deliberated on the outcomes of the results noting that the computed overall abstractions far exceed available resources in the study area.

The participants therefore embarked on deliberations on what measures that ought to be undertaken to address such issues under such conditions and came up with the following.

- Assessment of status and accuracy of data used
- It was noted that implementing a real time telemetric system for data acquisition and processing would enhance WAP implementation in a holistic manner and advance stakeholder ownership of the process.
- Rationalizing the network by converting a few automatic stations with data loggers to telemetric stations to ease O&M making it manageable and safeguard data integrity
- Stakeholder involvement and negotiation before implementation of WAP
- Review of the WEAP Modeling in collaboration with stakeholders to own the process
- Explore synergy with Mike Suite software for processing and updating model outcomes in near real time
- That Prototype Draft WAP be reviewed in collaboration with respective sub-basin stakeholders
- Forums to disseminate Draft WAP at sub-basin level with stakeholders before implementation are necessary for synergy, acceptance and ownership.

13. Conclusion and Recommendation

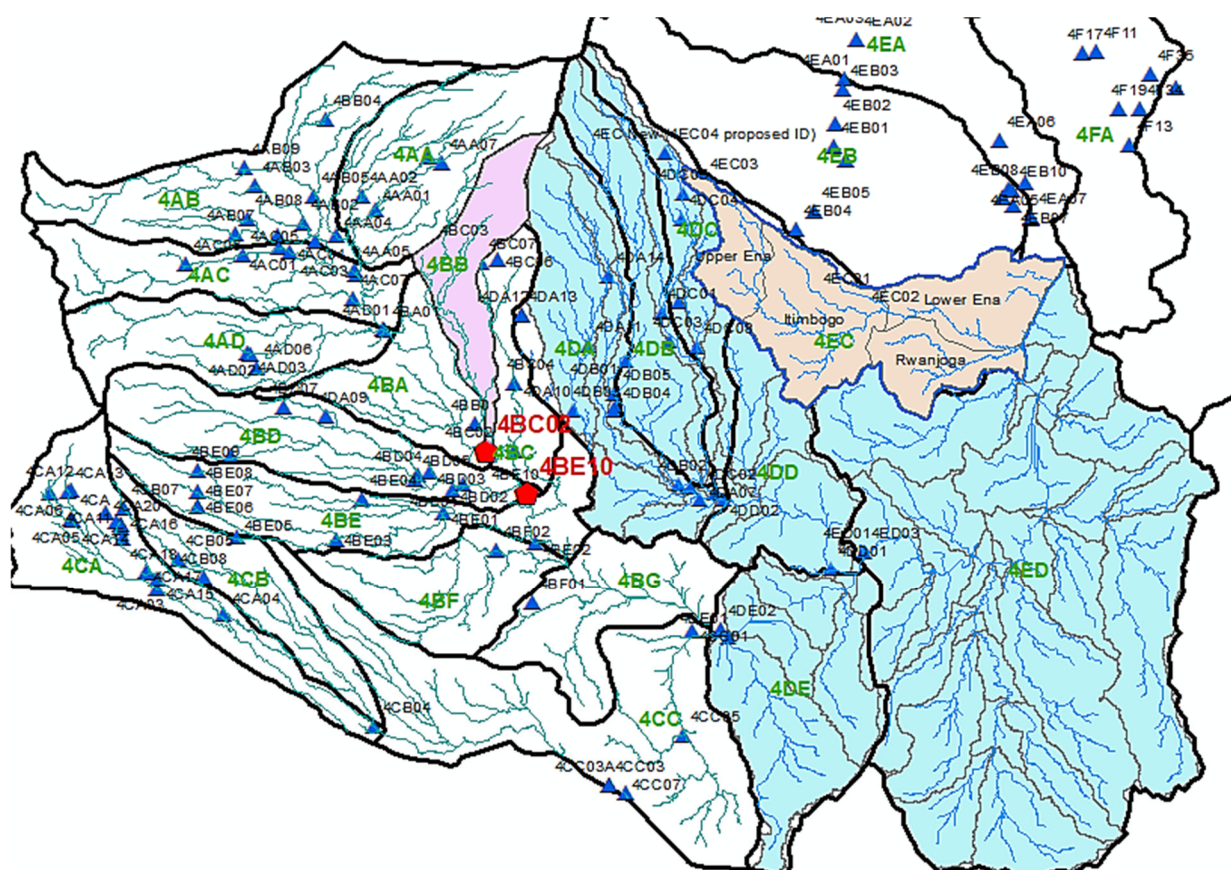
Following on the discussions, it is noted that utilization of a real time data acquisition and processing telemetric system would ably support development, enhancement and updating in near real time WAP. The added value is that WRA has in place working automatic stations which can be upgraded to telemetric status thereby providing adequate data to operationalize a monitoring network to support flood and drought early warning system.

Additionally, WRA Staff have limited capacity to formulate and sustainably operate such a system due to costs and resources. Capacity building in WEAP modeling and Mike Suite applications is required to support further development of a better version of WAP with stakeholder consultation before adoption by WRA.

After implementing the tasks above then formulation and operationalization of a manageable flood and drought early warning system becomes a reality and may thus be initiated with the limited and upgraded monitoring network. It is therefore recommended as follows:-

- That a few automatic data logger stations be upgraded to telemetric stations
- That for purposes of JICA-WRA Advisory Pilot Sub-basins, the telemetric stations at **RGS 4CA03, RGS 4BC02** and the logger station at **RGS 4BE10** be selected pilot station for WAP document formulation. Stations 4BC02 is upstream of 4BE10 while RGS 4CA03 is upstream further upstream of RGS 4BC02 and far away from the identified flood prone area compared which is downstream of RGS 4BE10 (See map attached).
- That BD and JICA-WRA Team support and collaborate to consolidate the WAP process and stakeholder participation. That BD and WRA be requested to install a diver at RGS 4BE10 to monitor water level, electrical conductivity and temperatures. BD suggested to assist WRA with 20 diver units as per discussions with them on the 18th September 2023 meeting.

The location of RGS 4BC02 and RGS 4BE10



Schematic Location of Stations

Status Report on Selected Stations-4BC02

A Station Information			
1	Station ID	4BC02	
2	River Name	Sagana	
3	Coordinates	latitude	-0.6725
		longitude	37.20417
		altitude	1193
4	Sub Basin	Upper Tana	
B Controls			

1	Is there a natural or an artificial control?	Natural
2	Is a stable (natural) controls present in the form of bedrock outcrop or other stable material during low flow and a channel constricted for high flow, or a fall of cascade that is un-submerged at all stages to provide a stable relationship between stage and discharge ? If not, then specify.	Channel control, straight river reach >100m, well vegetated banks, rock outcrops, channel constricted. However it was noted that the right bank is eroded next to the gauge location.
C Bench mark		
1	Is there a bench mark?	No
2	Is it in good shape?	N/A
D Equipment		
1	Are there staff gauges installed, what size (1, 1.5 or 2.0 m) and how many?	No. Vandalism reported on 14/08/2009.
2	Are the staff gauges 100% well-functioning?	N/A
3	Is any automatic water-level recorder installed?	Yes; SEBA Telemetry equipment
4	Is the water-level recorder 100% well-functioning?	Yes
5	Is there any kind of permanent discharge measurements installation?	No
6	Is the discharge installation 100% functional?	N/A
E Discharge measurements		
1	Has a proper location been identified for carrying out discharge measurements?	Yes; approximately 100m upstream of the gauging station sites at the Bridge
2	What is the estimated flow range (m/s) from low flow to flood flows	-
3	What is the expected flow depth range (m) from low flow to flood flow	-
4	Flood marks will be identified.	Riparian vegetation at the left bank
5	What kind of method is proposed for discharge measurements?	ADCP tethering, Current meter from the Bridge
F Accessibility		
1	What is the distance in km between the regional/sub-regional offices, from where the station will be handled?	15km from Murang'a Sub Regional office
2	How long does it take to drive by car to the station from the regional/sub-regional office from where the station will be handled?	10 minutes
3	Can a good and accessible site be identified for proper collection of water quality samples, i.e. is there a possibility to combine SW and WQ measurements?	Yes
G Observer		
1	Is there already an observer collecting data from the station?	No
2	Is there already an identified substitute observer that will take over those days the primary observer cannot be absent?	N/A

3	Have the observers been performing well in terms of doing the readings properly, continuously and on time?	N/A
4	Have there been a regular payment and supervision of the observers?	N/A
5	Is the observer normally provided with the necessary stationeries and equipment	N/A
H	Station Photos	
	 	

Status Report on Selected Stations-4BE10-Tana Rukangu

A	Station Information			
1	Station ID	4BE10		
2	River Name	Tana River at Rukanga		
3	Coordinates	latitude	-0.72799	
		longitude	37.2590	
		altitude	1106	
4	Sub Basin	Upper Tana		
B	Controls			
1	Is there a natural or an artificial control?	Natural		
2	Is a stable (natural) controls present in the form of bedrock outcrop or other stable material during low flow and a channel constricted for high flow, or a fall of cascade that is un-submerged at all stages to provide a stable relationship between stage and discharge ? If not, then specify.	Straight river reach>100m, rock outcrops downstream and rocky river bed.		
C	Bench mark			
1	Is there a bench mark?	Yes. Pin in concrete about 50m on the left bank from the last staff gauge.		

2	Is it in good shape?	Yes
D	Equipment	
1	Are there staff gauges installed, what size (1, 1.5 or 2.0 m) and how many?	7No. (0-1.5m, 1.5-3m, 3-4m, 4-5m, 5-6m, 6-7m, 7-8m) on the left bank.
2	Are the staff gauges 100% well-functioning?	Yes. However, 3 rd gauge plate missing but the post is graduated
3	Is any automatic water-level recorder installed?	No. Logger house was submerged and equipment damaged. Logger house vandalized.
4	Is the water-level recorder 100% well-functioning?	N/A
5	Is there any kind of permanent discharge measurements installation?	No
6	Is the discharge installation 100% functional?	N/A
E	Discharge measurements	
1	Has a proper location been identified for carrying out discharge measurements?	Yes; approximately 20m downstream of staves
2	What is the estimated flow range (m/s) from low flow to flood flows	-
3	What is the expected flow depth range (m) from low flow to flood flow	0.6m to 8m
4	Flood marks will be identified.	Riparian vegetation, logger house, bare rock on the river banks
5	What kind of method is proposed for discharge measurements?	ADCP tethering, boat
F	Accessibility	
1	What is the distance in km between the regional/sub-regional offices, from where the station will be handled?	About 30km from Murang'a Sub Regional office
2	How long does it take to drive by car to the station from the regional/sub-regional office from where the station will be handled?	30 minutes
3	Can a good and accessible site be identified for proper collection of water quality samples, i.e. is there a possibility to combine SW and WQ measurements?	Yes
G	Observer	
1	Is there already an observer collecting data from the station?	Yes

2	Is there already an identified substitute observer that will take over those days the primary observer cannot be absent?	Yes
3	Have the observers been performing well in terms of doing the readings properly, continuously and on time?	Yes
3	Have there been a regular payment and supervision of the observers?	Yes
4	Is the observer normally provided with the necessary stationeries and equipment	Yes
H	Station Photos	
		

Progress of key tasks undertaken by Water Resources Advisor

OUTPUT 1- Hydrological Monitoring Network update accordance to the purpose of Observation

ACTIVITY		STATUS
1.1	Survey on recent flood and drought damages as well as countermeasures for such damages.	Daily review reports on floods and drought, reports from NDMA KMD and other stakeholders/ partners. Continuous collection of data related to flood and drought
1.2	Survey on support activities by other development partners in the file of water resources	Collaboration with Dutch Water Authority/ Blue Deal, Nairobi Water & Sewerage Company, Nairobi Water Fund Trust (NWFT), KENGEN & Kenya Space Agency. 1nr joint Capacity Building conducted in Embu 18-22 Sept 2023.
1.3	Clarification on the positions/purposes of each observation station from the viewpoint of flood and drought risk evaluation	Access to database at WRA HQs with station operational status. Develop Baseline assessment of the existing hydrological network with station inventory, data status, instrumentation and the Daily history file.
1.4	Review of monitoring plan of Tana Catchment Area from the viewpoint of effective utilization of the observation results	Review existing monitoring plan Data on discharge, water level, rating curves, abstraction survey and any other relevant data and information compiled and used as baseline information. Develop criteria for water balance analysis for the pilot basins.

OUTPUT 2-Capacity Building on Hydrological Monitoring

ACTIVITY		STATUS
2.1	Confirmation on operational status and analysis of issues on observation facilities and data transmission facilities	Mike Info/Workbench and GIS enabled maps for Interactive status determination, optimization, Reporting, pre-processing & hydrodynamic information product generation
2.2	Support on preparation of plan of operation for data transmission facilities	Framework for an Operation Plan on Data Transmissions , Depository; Hardware & Software, O&M)
2.3	Training of observation facilities and data transmission facilities	Installation of 4F13 WRA Framework for Upgrading facilities, Operationalizing data acquisition & transmission
2.4	Reinforcement of capacity on observation at site including preparation of H-Q curve	Preparation of Plan of operation for Data transmission. curves.

OUTPUT 3-Hydrological Monitoring Network update accordance to the purpose of Observation

ACTIVITY		STATUS
3.1	Quality Improvement Guidance and Preparation of Quality Control Standard	Review Quality Control, SOPs Access to data Servers at WRA and quantify the volume of missing data Propose Quality Improvement
3.2	Confirmation on the current status and improvement on operation and management of data base.	Requisite data required for populating pilot study sub-basins be availed to the project team as requested to assist in assessment of data quality integrity and assurance.

OUTPUT 4-Capacity Building on Hydrological Monitoring

ACTIVITY		STATUS
4.1	Guidance on Basic Analysis: Implementation on Flow Regime. Arrangement/Compilation & Probabilistic Analysis	Data set received from Sagana and Ena sub-basin used for basic analysis. These are identified because they have the necessary datasets required for the study and having water stress during low flow conditions. However, some data was not exhaustive enough to run in the model. Further request made for Raw data.
4.2	Analysis Climate Change Affect	Specific <i>El Nino</i> and <i>La Nina</i> effects incorporated in the decision-making tools. Identify additional monitoring Stations for the Installation of flood facilities.
4.3	Discussion and Compilation on the Function of WRA as well as Utilization of Monitoring Results aiming at Flood Damage Mitigation	Utilization of information products generated from study pilot project to assist in water use conflict resolution for replication by WRA to other sub-basins in the overall Tana basin. Identify critical Stations for flood and drought monitoring facilities.
4.4	Discussions and compilation on measures during droughts as well as utilization and analysis of monitoring results	Conduct further Hydrological and Meteorological monitoring and data analysis. Review Water Allocation Guidelines. Prepare materials and details related to information transmission, sharing, and disclosing information for access by other institutions Stakeholder Engagement.



TITLE: Meeting Attendance Form

DEPARTMENT: Planning, Research & Quality Assurance

ISSUED BY: Assistant Manager, Quality Assurance and Risk Management

AUTHORIZED BY: CEO

WATER RESOURCES AUTHORITY

REF. NO.: F/18/1

ISSUE NO.: 08

REV. NO.: 06

DATE OF ISSUE: 22 March 2022

Page 1 of 2

SUBJECT: WEAP WORKSHOP IN EMBU - WRA, JICA AND BLUEDEFAC

VENUE: Embu WRA BOARDROOM

DATE: 19/09/2023.

TIME: 10:00 AM - 5:00 PM

S/No	Name	Institution	Designation	Station	Gender		PWD	Age (Y)		Phone	Email Address	Signature
					M	F	Y/N	Below 35yrs	Above 35yrs			
1.	Tahya Aalen	WRA	Hydrologist	GSA	✓			✓				
2.	Chaboswong Kawele	WRA	Hydrologist	Koborone	✓			✓				
3.	SIMON MAKASA	WRA	License Officer	KITUY	✓				✓			
4.	ALEX KIMOSHO	WRA	Hyd	Mzani	✓				✓			
5.	JANE NINGUNA	WRA	Hydrologist	KEDUWY		✓			✓			
6.	DOREEN ILUBA	JICA	Admin	NRB			✓	✓				
7.	M.K. Magoni	WRA	PLD	Embu	✓							
8.	Deius Moiso	JICA	Hydrologist	NRB	✓				✓			
9.	Gerden Bernhard	PWA	HdSR	NL	✓			✓				

ATTENDANCE SHEET



TITLE: Meeting Attendance Form

DEPARTMENT: Planning, Research & Quality Assurance

ISSUED BY: Assistant Manager, Quality Assurance and Risk Management

AUTHORIZED BY: CLO

WATER RESOURCES AUTHORITY

REF. NO.: 17/07/1

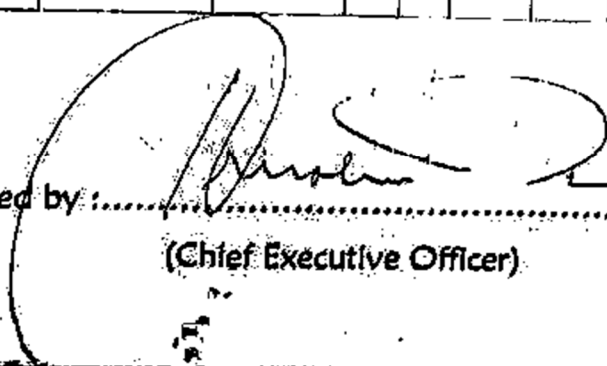
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DATE OF ISSUE: 22nd March 2022

Page 2 of 2

S/No	Name	Institution	Designation	Station	Gender	PWD	Age (V)	Phone	Email Address	Signature
10	Pauline Nyamuri	WRA	St. Hyacinth	Lindi	M	Y/N	Below 18yrs			
11	Epheumbe Werf	DWA	HO SR	NL	✓		✓			
12	Joram Kihumbi	WRA	Postdoc	EMBU	✓		✓			
13	Eugen Mwandoo	JICA	JICA Expert	NRB	✓		✓			
14	GILBERT MAITO	JICA	JICA Expert	NRB	✓		✓			
15										
16										
17										

Approved by: 

(Chief Executive Officer)

Appendix 10

**Online Lecture Material by the
“Telecommunication/Innovation
Technology” Expert on January 12, 2023**

2023 年 1 月 12 日

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

Yasushi Azuma

NIPPON KOEI CO., LTD.

Table 1 Selection of Water Level Gauge Type (1/4)

Type	Float Type (Well Type)	Sensing Pole Type (Lead Switch Type)
Diagram		
Gauging Theory	Water level is gauged by measuring rotation of a pulley that consists of a wire with float and weight on its both ends hang on.	Water level is gauged by a pipe with lead switches inside. Lead switches turn on by moving of a magnetic float in the pipe.
Incidental Equipment	- Observation well - Intake pipe - Gauging house	- Supporting Structure (concrete pipe or H type steel pipe) - Gauging house
Composition of Equipment	- Sensor (Float, wire, weight) - Transducer (gear, pulley, axle, recorder)	- Sensing pole - Lightening arrester - Transducer
Range of Gauging	10, 20, 50, 100 m	1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0 m
Accuracy of Gauging	F.S. +/- 0.1%	+/- 1.0 cm
Civil Works	Structures such as a well, gauging house, intake pipes and bank protections, comparatively, require large-scale civil works and cost.	Supporting pipes (H shape steel pile) need to be installed in the stream with small-scale civil works.
Maintenance	Float type sensor is easy to maintain, however maintenance is needed to keep the intake pipes clean.	Sensing pole type gauge is comparatively easy to be maintained. Drift woods and sedimentation caught around pole due to floods must be removed.
Cost (For reference only)	Approx. JPY6,510,000 (KES5,841,853 *) including the civil works	Approx. JPY7,043,000 (KES6,320,149) including the small civil works
Application to Gauging Station	- Float type gauge is used generally due to easy maintain. So, the float type was used in past time. - Float type gauge generally costs much for civil work such as the well.	- Sensing pole type gauge was to the applied in more than 30 years ago and the magnet detecting water level has stopped manufacturing. - Sensing pole type gauges are presently not available.

* 1JPY=KES 0.91

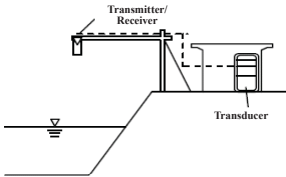
Table 1 Selection of Water Level Gauge Type (2/4)

Type	Pressure Type	Quartz Type
Diagram		
Gauging Theory	Sensor in the water gauges variation of water pressure which reflects the water level. The sensor consists of ceramic material.	The sensor consists of quartz material and theory is same as the pressure type.
Incidental Equipment	- Protection pipe of sensor - Gauging house	- Protection pipe of sensor - Gauging house
Composition of Equipment	- Pressure type sensor - Relay box with surge protection devices - Transducer	- Quartz type sensor - Relay box surge protection devices - Transducer
Range of Gauging	4, 10, 20, 40 m	10, 20, 30, 50, 70, 100 m
Accuracy of Gauging	F.S. +/- 0.1% (Calibration might be required for installing in the estuarine or sea water)	F.S. +/- 0.02, 0.02, 0.05% (Calibration might be required)
Civil Works	Small-scale civil works such as supporting structure (pile in the water, bank protection) for protection pipe of sensor.	The same as pressure type
Maintenance	Removal of sedimentation or deposit on the sensor is needed.	The same as pressure type
Cost (For reference only)	Approx. JPY1,990,000 (KES1,785,758) including the small civil works	Approx. JPY4,525,000 (KES4,0607,606) including the small civil works
Application to Gauging Station	- Pressure type gauge is most reasonable for both price and accuracy.	- Quartz type gauge is much more expensive than pressure type due to its high accuracy. - High accuracy of quartz type is applied to measure water level in dam site where high accuracy measurement is needed.

Table 1 Selection of Water Level Gauge Type (3/4)

Type	Ultrasonic Type	Rader Type
Diagram		
Gauging Theory	Ultrasonic type sensor is set above water surface. The sensor transmits supersonic waves vertically, and receives reflection waves. Water level can be estimated with a time lag from the transmission to receiving waves. This type of sensor is used in mountainous area where river flow including sediment and bad access load.	Rader type sensor is set above water surface. The sensor transmits electric microwaves vertically, and receives reflection waves. Water level can be estimated with a time lag from the transmission to receiving waves.
Incidental Equipment	- Pole for mounting sensor (it is not required if sensor is mounted on a bridge beam) - Gauging house	- Pole for mounting sensor (it is not required if sensor is mounted on a bridge beam) - Gauging house
Composition of Equipment	- Sensor (supersonic wave transmitter/receiver) - Thermometer - Relay box - Transducer	- Sensor (microwave transmitter/receiver) - Relay box - Transducer
Range of Gauging	Measurable range from water surface to sensor is limited to 0.6 - 15 m	Measurable range from water surface to sensor is limited to 0.5 - 20 m
Accuracy of Gauging	Distance from sensor to water surface 0.6 m to 10.6 m +/- 1cm 10.6 m to 15.6 m: +/- 2cm (if no wind/wave)	+/- 1 cm
Civil Works	Civil works are not required generally except sensor pole. Sensor needs a pole to mount, which must be unaffected by strong wind (generally by wind velocity of 50 m/s).	The same as ultrasonic type
Maintenance	Maintenance of sensors mounted on the pole requires scaffoldings such as stages or cranes.	The same as ultrasonic type
Cost (For reference only)	Approx. JPY4,498,000 (KES4,095,660) including the small civil works	Approx. JPY3,866,000 (KES3,469,217) including the small civil works
Application to Gauging Station	- Ultrasonic type sensor is easy to install and is more expensive and slightly less accurate than pressure type. Additionally, it involves a problem of vandals.	- Same as the Ultra sonic type.

Table 1 Selection of Water Level Gauge Type (4/4)

Type	Laser Type	Water level logger type
Diagram		
Gauging Theory	Laser type sensor is set above water surface. The sensor transmits laser vertically, and receives reflection waves. Water level can be estimated with a time lag from the transmission to receiving waves.	It is a low-cost, research-grade water level data logger for continuously measuring water level and temperature in a wide range of underwater environments. This data logger operates in outdoor and underwater environments
Incidental Equipment	- Pole for mounting sensor (it is not required if sensor is mounted on a bridge beam) - Gauging house	- Wire for the sensor - Optical interface devices for the data reading - Software (at free)
Composition of Equipment	- Sensor (laser transmitter/receiver) - Relay box - Transducer	- Sensor - Optical interface devices 
Range of Gauging	Measurable range from water surface to sensor is limited to 3 - 50 m	Approximately 0 to 4 m of water depth at sea level with 69 to 145 kPa
Accuracy of Gauging	Distance from sensor to water surface 0.6 m to 10.6 m: +/- 1cm 10.6 m to 15.6 m: +/- 0.1% F.S.	Depths: 13 feet (3.96 m) +/- 0.1% FS (+/- 0.4 cm) 9 m +/- 0.1% FS (+/- 1 cm) 30 m +/-0.1% FS (+/- 3cm)
Civil Works	Civil works are not required generally except sensor pole. Sensor needs a pole to mount, which must be unaffected by strong wind (generally by wind velocity of 50 m/s).	Small-scale civil works such as supporting structure (pile in the water, bank protection) for protection pipe of sensor.
Maintenance	Maintenance of sensors mounted on the pole requires scaffoldings such as stages or cranes.	Battery life is 5 years with 1minute or greater logging interval.
Cost (For reference only)	Approx. JPY5,607,000 (KES5,031,531) with small civil works	Approx. JPY89,000 (KES 75,000) without a civil works
Application to Gauging Station	- Same as the Ultra sonic type.	

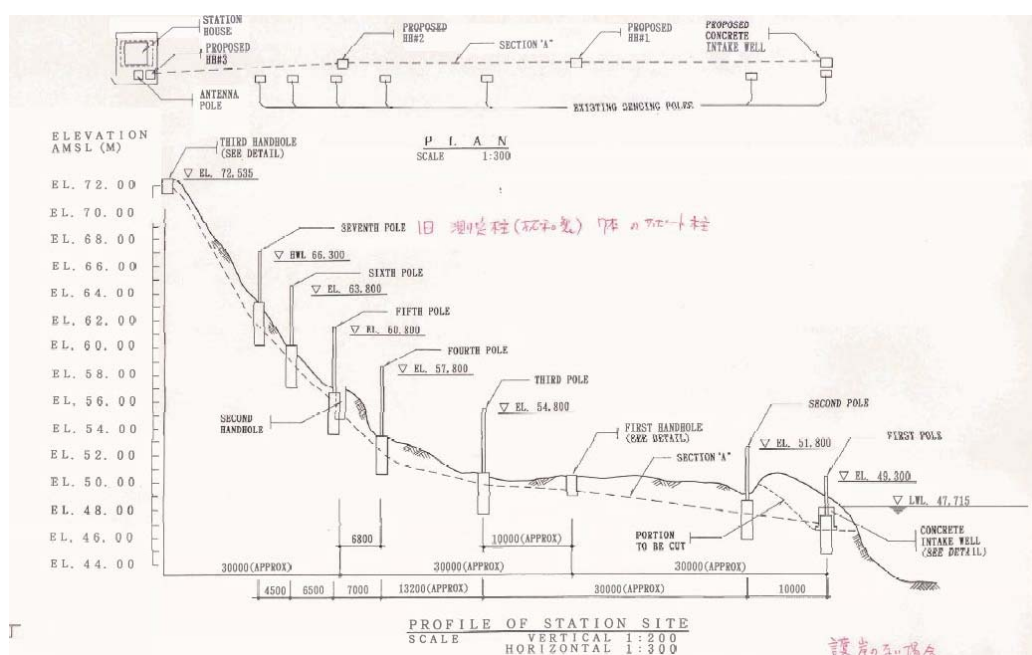
Installation Example 1: Sensing Pole Type

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:

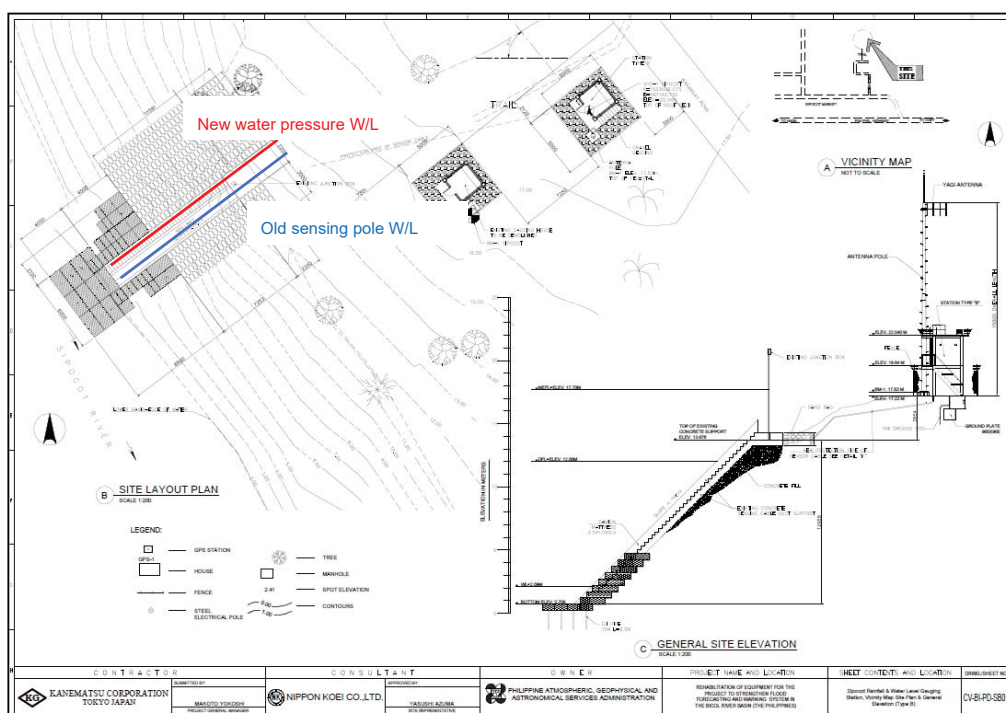
- Proper maintenance works can extend the length of equipment life
- Trainings to conduct the proper operation and maintenance (O&M) works are essential
- Such requirements shall be added to a contract for procurement of equipment and select good vendor(s)/manufacturers

Installation Example 2: Sensing Pole Type W/L and telemetry equipment

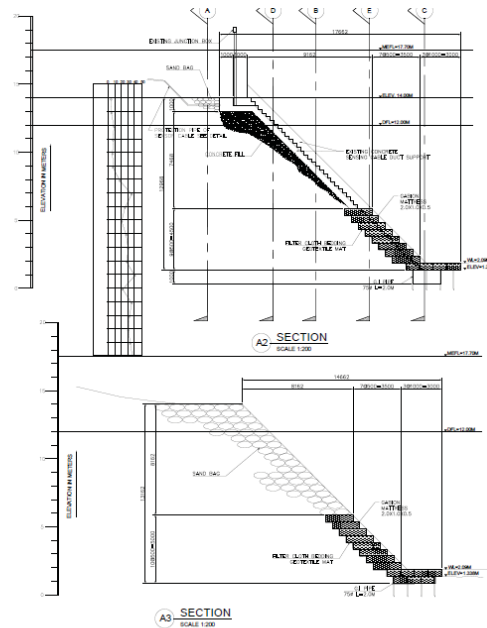
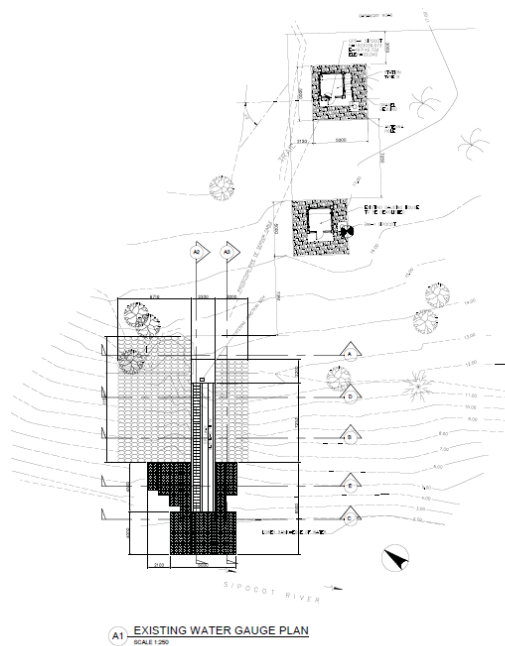


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Installation Example 3: Sensing Pole Type and pressure type water level sensor



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Features of this site: rehabilitation works have conducted.

Gauging House	Water Level Structure	Bank Protection
The gauging house has not deteriorated but it was flooded. - Gauging house should be replaced on higher ground behind the existing house.	Water level structure is installed on riverbank slope. A part of the slope under the structure was eroded (there is cracks in the concrete as the structure is hanged over the eroded slope). There also seems one more unstable block on the slope under the structure	Foundation slope of the water level structure is eroded and has unstable block. - Restoration and countermeasure for eroded slope and unstable block are required.
		Rehabilitation work: see below.

Rehabilitation works

For the hydrological problem, new gauging house should be installed as same dimension but the floor will set above the past highest water level.

On the other hand, for structural problem, countermeasures mentioned below will be needed,

a) Filling concrete carefully into the eroded part under the existing structure to prevent the crack in the structure

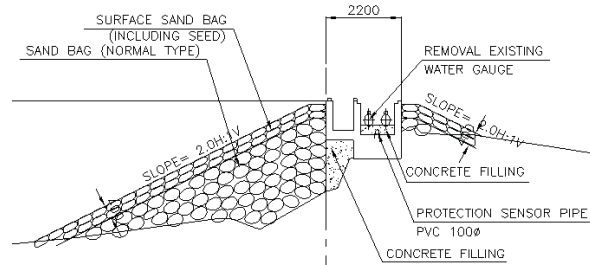
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aggravating,

- b) Protecting the slope surface by sandbags and gabions in order to prevent erosion aggravating.
- c) Providing rock bolt works in the unstable slope and providing gabions as foot protection to make the slope more stable
- d) Slope Stability Analysis is required

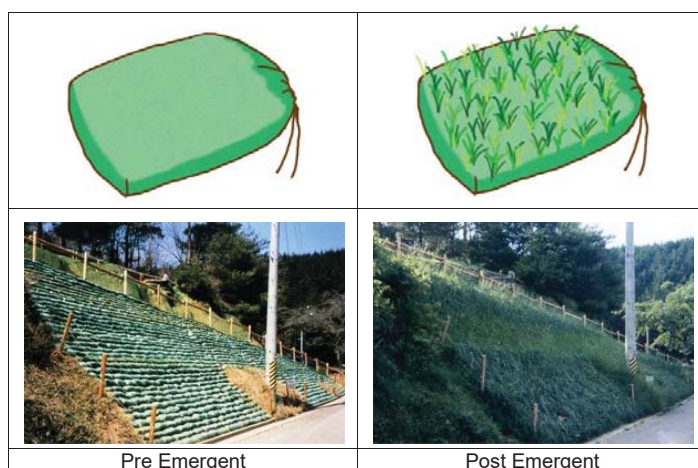
Rehabilitation design of existing structures is carried out under the following policy.

- Erosion part of the structure should be filling concrete.
- Upstream and downstream sides of the existing structure should be protected by sandbags (including seed), and
- Gabion Mattress is installed in the lower part. (Height =5.0m)



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Sandbags (including seed) are generalized method of slope protection measure in Japan. Sandbags are included seed and fertilizer, and short grass will germinate in about 3-months from sandbags. Sandbags will be integrated with the existing slope.



Total cost of the rehabilitation civil works is JPY 35,232,000, which is approx. 8.7 times against the equipment cost. Total cost of the telemetry equipment is JPY 4,035,000.

What we want is the cost of the civil works will be expensive one in some case.

11

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

January 12, 2023

Nippon Koei Co., Ltd.

Kenya Water Resources Advisor

Installation works of the pressure type W/L

Background of the project (Technical Cooperation under JICA):
The dam is owned and operated by a private company
Water release from the dam is responsible of former owner (NPCOR) and
PAGASA, National weather forecasting organization in the Philippines
To date sharing of dam water reservoir between the private dam
operator and NPCOR/PAGASA
Installation of Telemetry Equipment is need for proper dam operation
Lessons learned:
Many water level sensors were broken by the lightning strike, which is
very difficult to protect completely from such natural phenomenon
Procurement plan for spare parts is important



install a pipe for the water level sensor on the
existing dam structure on May 2011.
Project site is Northern Luzon, Philippines

Installation works of the pressure type W/L



Install the pipe using crane

Installation works of the pressure type W/L



To install the pipe and the water level sensor cable

Installation works of the pressure type W/L



To install the pipe, the water level sensor cable and outlet box

Installation works of the pressure type W/L



To install the solar charge panel and data logger equipment

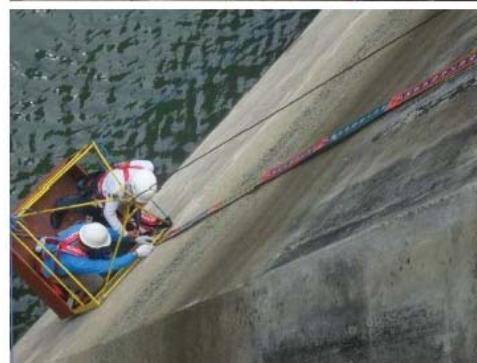
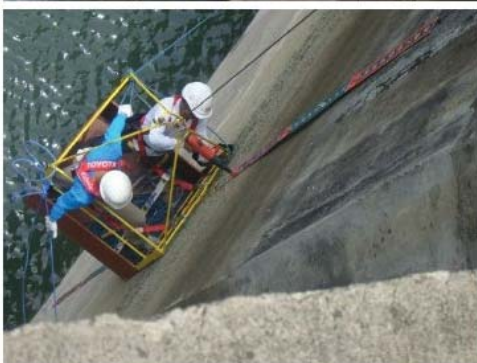
To install the solar panel

Installation works of the Staff Gauges



Installation of staff gauge at Pantabangan Main Dam Slope. Starts on April 13, 2011 and accomplished on April 28, 2011 from Elevation 194.00 m to 222.00 m and high WL at 225.00 m.

Installation works of the Staff Gauges



Installation of staff gauge at Masiway dam. Starts on May 4, 2011, 8:00 am. and accomplished on May 4, 2011, 2:00 pm from Elevation 122.00 m to 130.00 m attached to the vertical right side of spillway gate Number 1 facing upstream.

Installation works of the Staff Gauges



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

January 12, 2023

Nippon Koei Co., Ltd.

Kenya Water Resources Advisor

Contents

1. Image Type of Water Level Gauge

- General
- System configuration
- Estimated Cost

2. Water level sensors for Risk Management of River

- Ultrasonic type
- Water level sensor using Raspberry Pi (small computer)

3. Flood Monitoring with Flood Sensor

- System configuration
- Estimated Cost

4. Sensors to detect a flood- the verification tests in Japan year 2022

5. Telecommunication Systems for Telemetry system

6. Type of LPWA (WPWAN)

1. 1 General of Image type Water Level (W/L) Gauge

Main Features

- This equipment can measure water level automatically.
- This equipment can detect water level from pictures taken by camera.

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

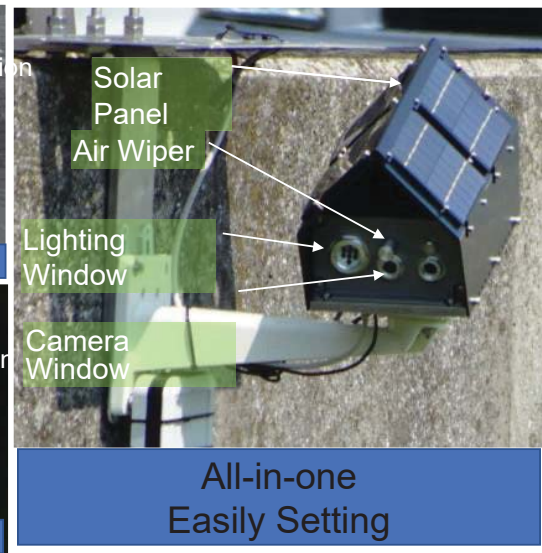
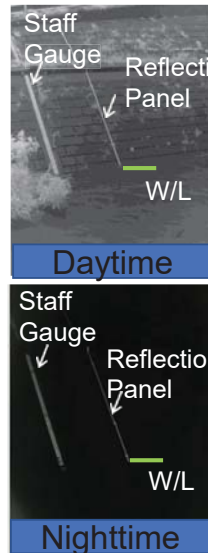
- All-in-one box
- wireless communication system
- Solar panel

③ Measurements for nighttime and heavy rain

- Stable measurement
- Air wiper

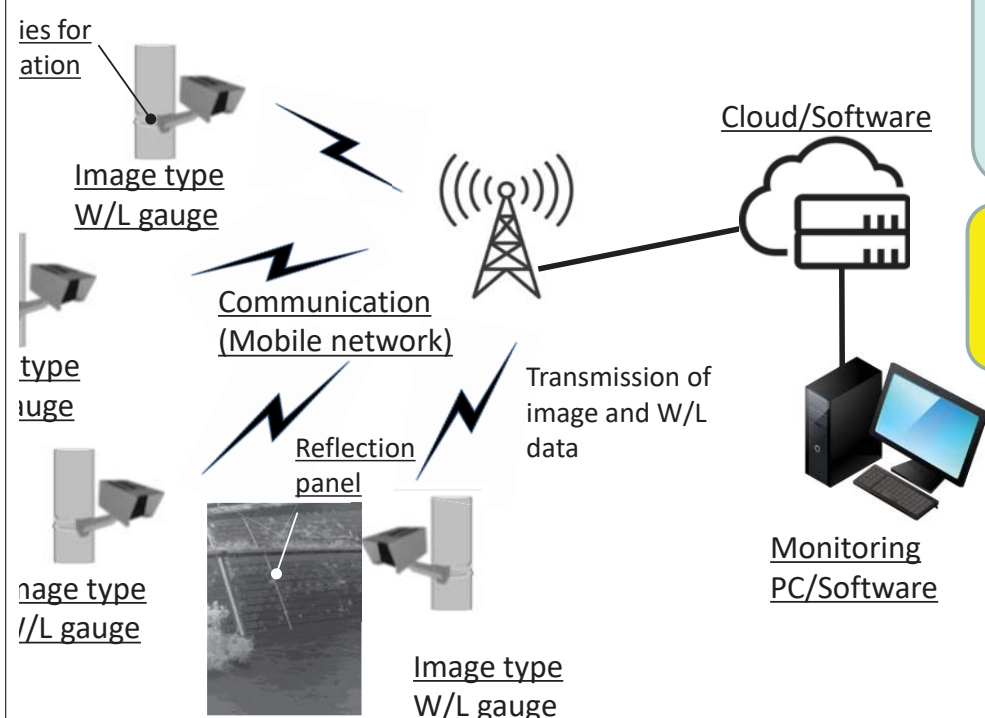
④ Low cost

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



3

1.2 System configuration of the Image type W/L gauge



Challenges

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

Solution

Water level gauge reading by (Automatic)

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1. 3 Estimated Cost

Cost of Image type W/L Gauge

		Unit price	Q'ty		Initial cost (USD)	operation cost/3year (USD)	Note	Basis for pricing
Equipment	Image type W/L gauge	9,000	7	unit	63,000			Target unit price of Crisis Management Water Level Meter
	Facilities for installation	900	7	unit	6,300			Pole etc.
	Refraction panel	900	7	unit	6,300			Web surveyance (Water mark, retroreflective sheet)
Cloud server	Cloud fee	900	36	month		32,400		Estimated Price
	Software fee	4,500	36	month		162,000		Estimated Price
Monitoring	PC	2,600	2	unit	5,200			Estimated Price
Communication		20	252	month*unit		5,040	3G or above	Price from ITU Database
Shipping		13,000	1	LS	13,000			Estimated Price
Installation	Labor cost (Local)	300	70	Man-day	21,000			Assumed Price based on experience
Test	Pre adjustment for server	900	10.5	day	9,450		Japanese (900USD/day)	Direct labor costs of JICA
	Combination test for server	900	7	day	6,300		Japanese (900USD/day)	Direct labor costs of JICA
	Combination test at site	900	7	day	6,300		Japanese (900USD/day)	Direct labor costs of JICA
Resident manager (Japanese)		900	60	day	54,000		Japanese (900USD/day)	Direct labor costs of JICA
Expenses	Travel cost	3,000	4	roundtrip	12,000		Japan-SiemReap	Estimated Price
	Per diem	49	240	Man-day	11,760			Estimated Price
	Accommodation	100	240	Man-day	24,000			Estimated Price
Spares (Image type W/L gauge)		9,000	2	unit	18,000			Target unit price of Crisis Management Water Level Meter
Maintenance (Local)		300	168	Man-day		50,400	Local	Assumed Price based on experience
Maintenance (Japanese)		900	60	day		54,000	Japanese (900USD/day)	Direct labor costs of JICA
Total					256,610	303,840		

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2.1 Water level sensors for Risk Management of River

(1) Ultrasonic type



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)

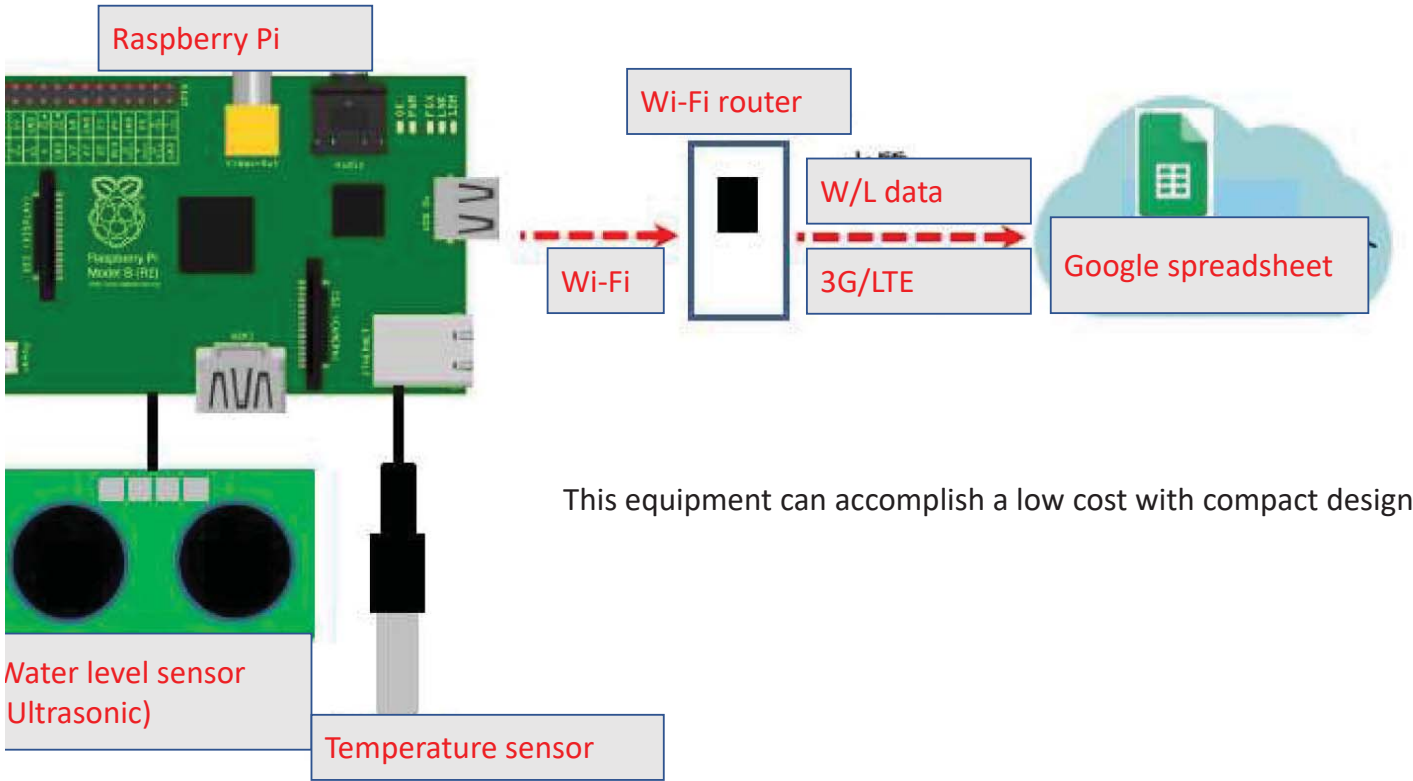
This equipment is developed to accomplish a low cost with compact design, and easy installation, particularly for small to mid-sized rivers

Water level data is monitored real-time

Appendix 10 Presentation Material by Mr. Y. Azuma (Telecommunication/Innovation Technology) on January 12, 2023 -14

2.2 Water level sensor using Raspberry Pi (small computer)- experiment

(2) Ultrasonic type+ Raspberry Pi



3.1. General of Flood Monitoring with Flood Sensor

Main Features

- Detection of flood area with small and cheap devices
- Realtime monitoring flood area by smartphone

functions and specifications

①Flood Sensor

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



②Aggregate Router

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

③Realtime Monitoring Flooded Area

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



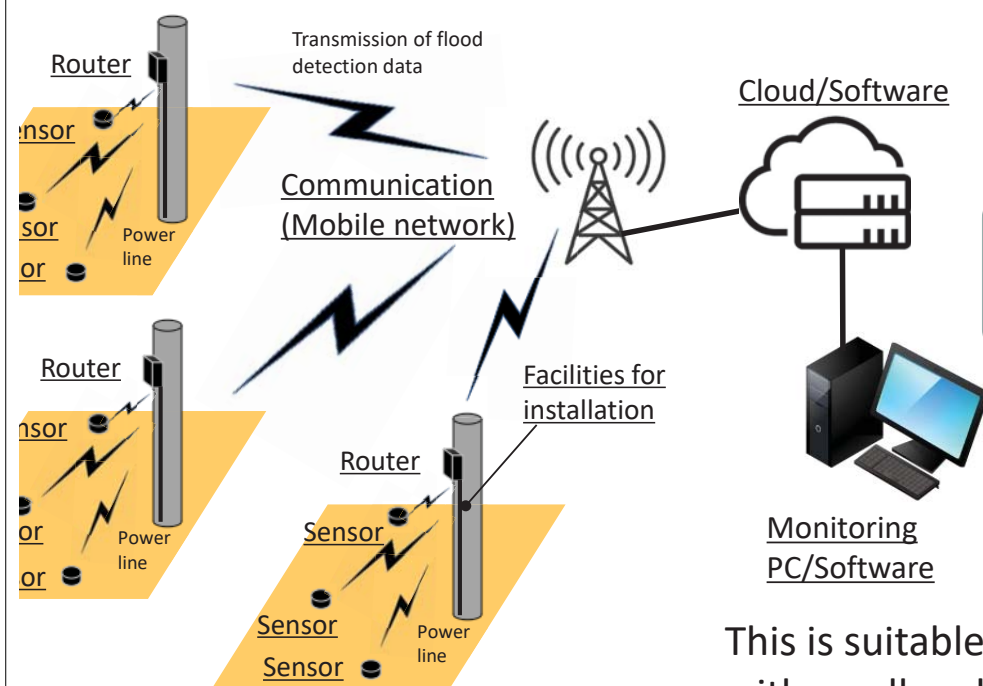
3.2 System Configuration of the Flood Monitoring with Flood Sensor

Challenges

- Detection flood is by manual
- It takes time to inform the detected flood to inhabitants

Solution

Flood Monitoring with Flood Sensor



This is suitable for the detection of the flood with small and cheap devices and can be monitored with a smartphone.

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3.3 Estimated Cost

		Unit price	Q'ty		Initial cost (USD)	operation cost/3year (USD)	Note	Basis for pricing
Equipment	Router	2,600	10	unit	26,000			Estimated Price
	Sensor	5	30	unit	150			Web surveyance (JOTSU)
	Facilities for installation	900	10	unit	9,000			Pole etc.
Cloud server	Cloud fee	900	36	month		32,400		Estimated Price
	Software fee	4,500	36	month		162,000		Estimated Price
Monitoring	PC	2,600	2	unit	5,200			Estimated Price
Communication		20	360	month*unit		7,200	3G or above	Price from ITU Database
Shipping		13,000	1	LS	13,000			Estimated Price
Installation	Labor cost (Local)	300	90	Man-day	27,000			Assumed Price based on experience
Test	Pre adjustment for server	900	15	day	13,500		Japanese (900USD/day)	Direct labor costs of JICA
	Combination test for server	900	10	day	9,000		Japanese (900USD/day)	Direct labor costs of JICA
	Combination test at site	900	10	day	9,000		Japanese (900USD/day)	Direct labor costs of JICA
Resident manager (Japanese)		900	80	day	72,000		Japanese (900USD/day)	Direct labor costs of JICA
Expenses	Travel cost	3,000	4	roundtrip	12,000		Japan-SiemReap	Estimated Price
	Per diem	40	320	Man-day	12,800			Estimated Price
	Accommodation	100	320	Man-day	32,000			Estimated Price
Spares (Router)		2,600	3	unit	7,800			Estimated Price
Spares (Sensor)		90	9	unit	810			Web surveyance (KOYO MUSEN)
Maintenance (Local)		300	168	Man-day		50,400	Local	Assumed Price based on experience
Maintenance (Japanesse)		900	60	day		54,000	Japanese (900USD/day)	Direct labor costs of JICA
Total					249,260	306,000		

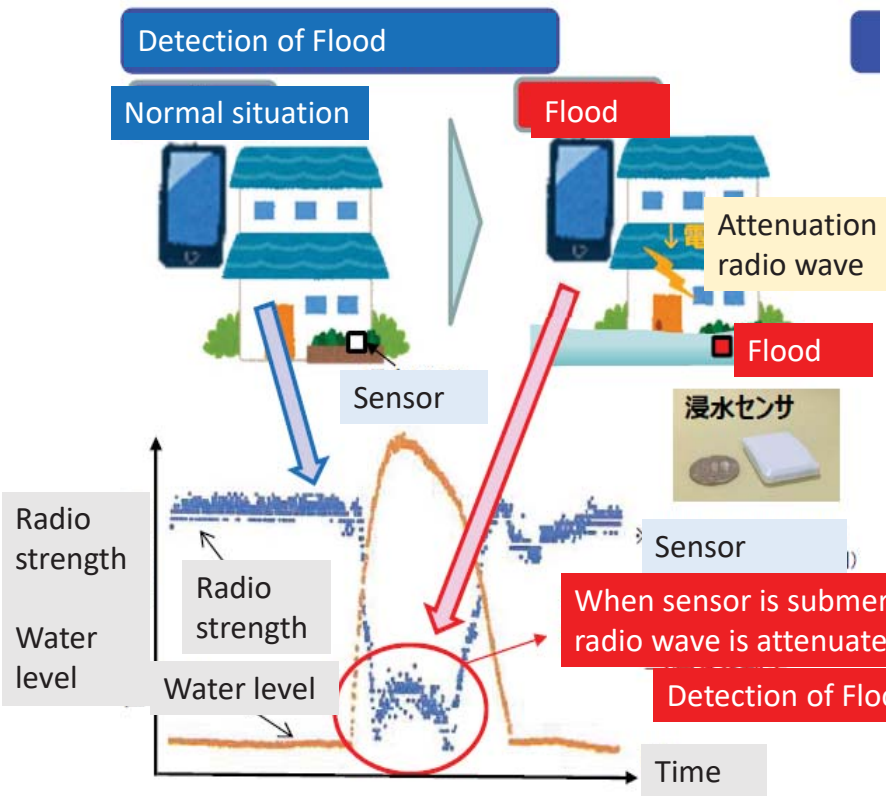
4. Sensors to detect a flood- the verification tests in Japan year 2022



sensor made by taiyoyuden



September 12, 2022: one sensor out of 9 pcs detects the flood.

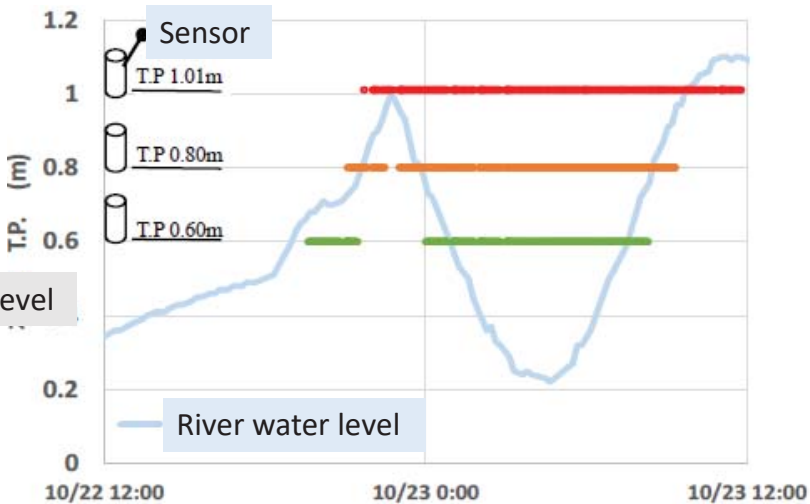
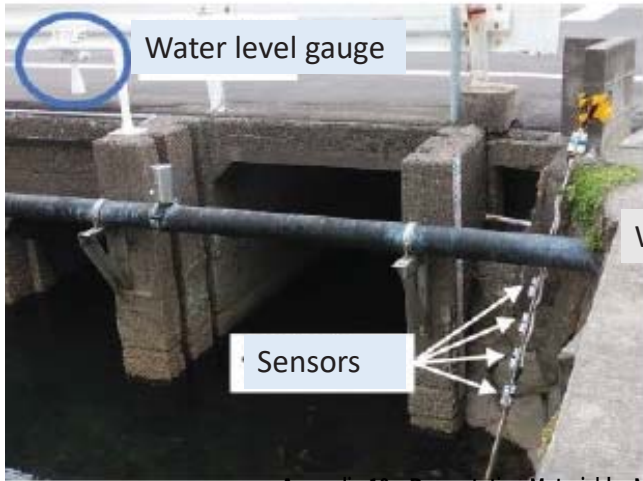


4. Sensors to detect a flood- the verification tests in Japan year 2022

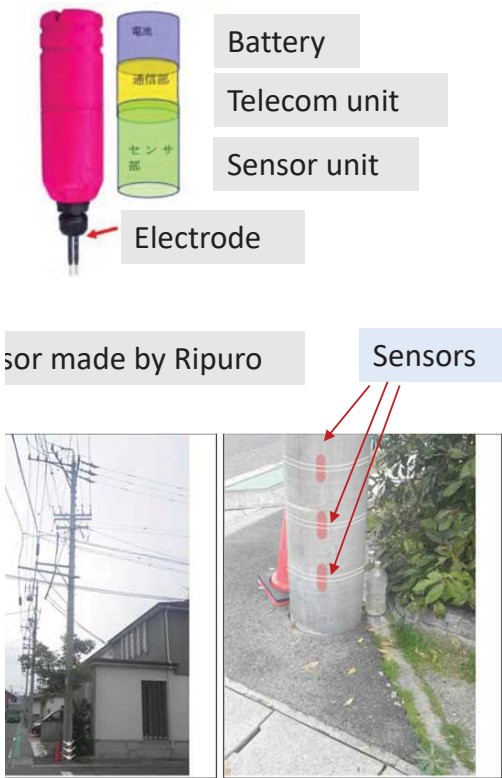


Sensor made by Nita-Consultant

River water level is compared with the measured data with the water level sensor.
Detection of water level with the sensor almost same with the data by water level gauge



4. Sensors to detect a flood- the verification tests in Japan year 2022



Monitoring of flood detection with GIS application- green color denote the sensor to detect the flood.

Telecommunication system: LPWA (Low Power Side Area) 100m - 1 km

5. Telecommunication Systems for Telemetry system

Type	Distance	Transmission Speed
LPWA (Low Power Wide Area)	< 50 km via repeater	250 kbps
3G/LTE/5G	LTE: Approx. 6 km 5G: Approx. 500m	3G: - 14 Mbps LTE: 75 – 100/150 Mbps 5G: >Approx. 10 Gbps
Wi-Fi	Approx. 50 – 100 m	IEEE802.11ac: 1 Gbps
Bluetooth	Approx. 10 m	2 Mbps
VHF/UHF radio: legacy technology	5W 10-30 km	2400 bps

- There are many standards of LPWA (see next page).
- 3G/LTE are operated by a communication companies (Carrier) in each country.
- In Japan, VHF and UHF radio are standardized for the telemetry/warning system in MLIT (Ministry of Land, Infrastructure, Transportation and Tourism)

6. Type of LPWA (WPWAN)

Type	Bit rate (kbps)		Licensee	Features
	Up-stream	Down-stream		
LoRaWAN	0.3 - 50		No need	- Transmission distance: 10 -20 km - Stable data transmission
NB-IoT	100	600	No need	- Transmission distance: Max. 50 km - Limitation of usage per day - Operational cost is good
4G Cat.M1	1M	0.8M	Need	- Device can connect to Internet - Voice communication
5G RedCap	63	27	Need	- Easy connection under LTE - Suitable for Smart-meter



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

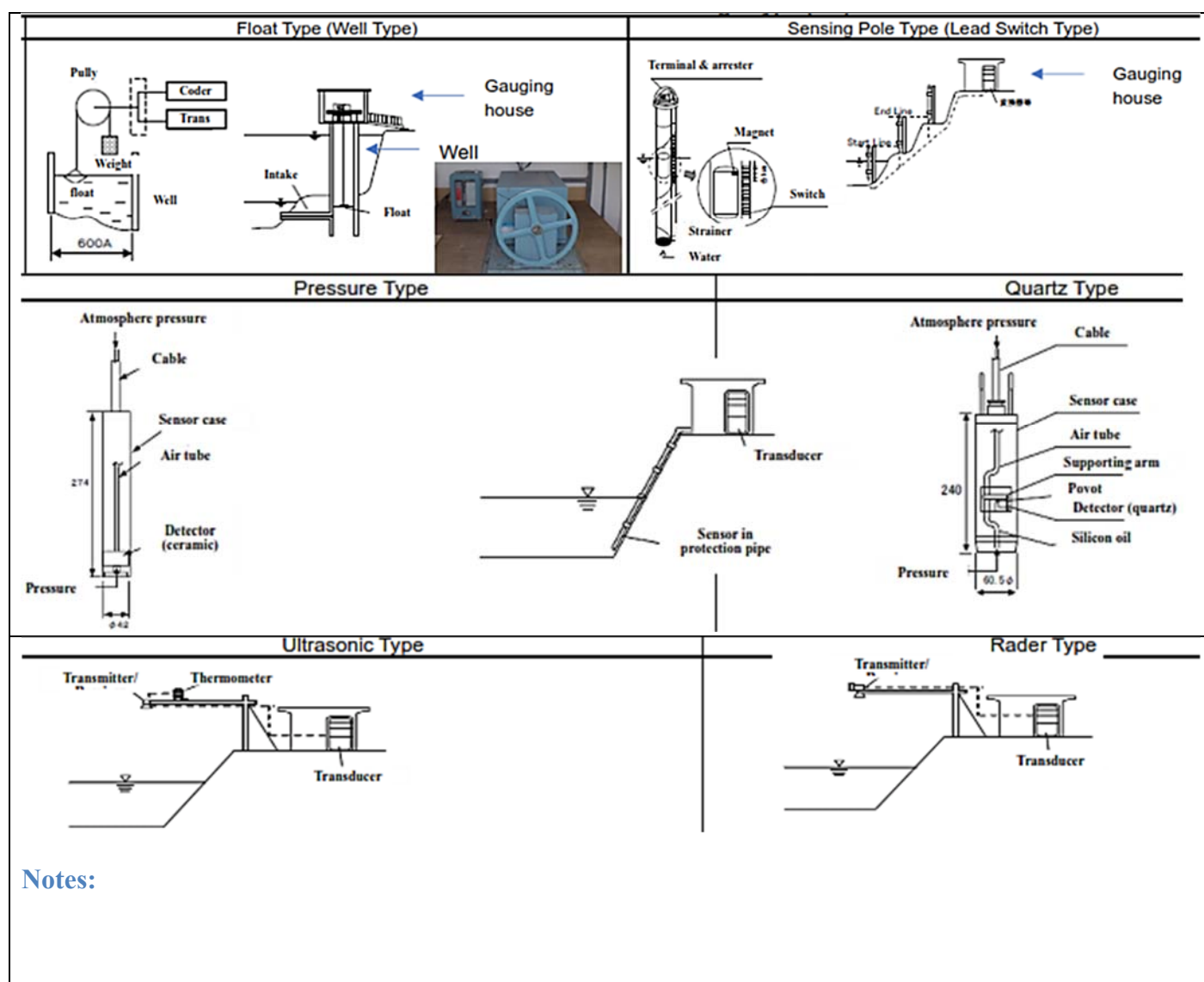
- Operational challenges were identified, such as missing data for existing telemetric stations.
- Additional capacity building on telemetric and automatic raw data handling archiving quality check and analysis.
- Review of Data Management Plan with combined or multiple WL gauge facilities for time series

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

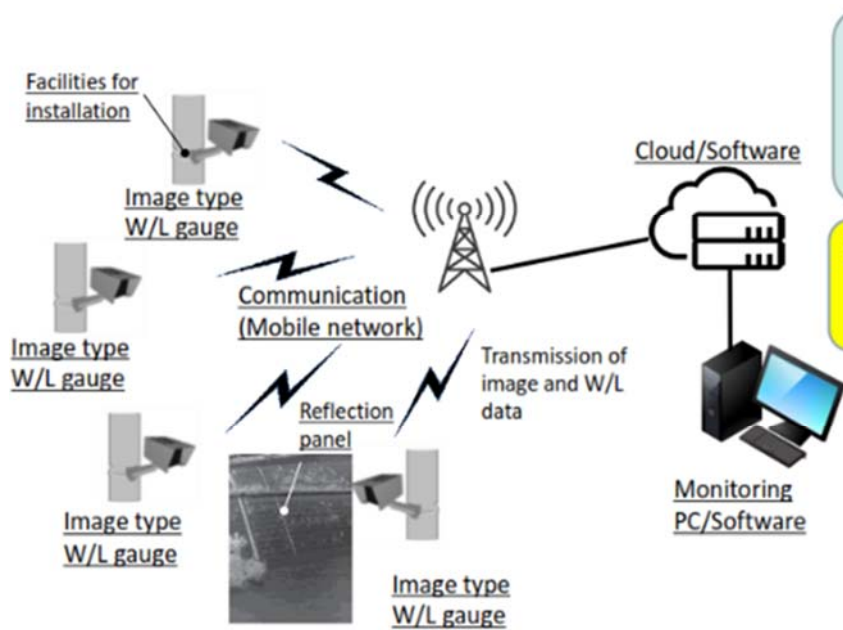
- Target price is 1 million JPY (KES907,847)



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:

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

①Flood Sensor

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



②Aggregate Router

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

③Realtime 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:

List of Participants

#	Name	Designation	Area/Office	Email Address
1	Reuben Ngesa	Assistant Manager Hydrology	WRA_Head office	reubenngessa@gmail.com
2	Lee Baraza	Assistant Manager Water Resources Data	WRA-Head Office	leebarasa2@gmail.com
3	Jared Otieno	Project Coordinator	WRA-Head Office	Jotieno98@gmail.com
4	Kennedy Ochieng	Project Coordinator	WRA-Head Office	kenmulla12@gmail.com
5	Josiah Maina	Senior Water Resources Data/ICTO	WRA-Head Office	jowaboyo@gmail.com
6	Abdi Omari	Basin Area Coordinator	Embu Regional Office	abdiyare.omari2018@gmail.com /
7	Jackline Mutinda	Regional Technical Manager/Principal WRSO	Embu Regional Office	jmmutinda@gmail.com
8	Eric Busiega	Chief ICTO	Head Office	ebusiega@gmail.com
10	Samuel Wanjohi Ndungu	Surface Water Officer	Embu Regional Office	ndungu.wanjohi@yahoo.com
11	Wilson Ndirangu Githu	Senior ICTA	Embu Regional Office	willygithu@gmail.com
12	Lucy Wamuyu Fundi	SBAC- Sub Basin Area Coordinator	Kerugoya	lucy.fundi@yahoo.com
13	Jane Wanja Njuguna	Hydrologist	Kerugoya	janenjguna42@yahoo.com
14	Faith Wanja Mbathi	Hydrologist	Muranga	fwmbathi@gmail.com
15	Jane Wairimu Njoroge	Hydrologist	Muranga	janenjoroge35@yahoo.com
16	Patricia Musau	Ag. Sub Basin Area Coordinator	Muranga	musaupat@gmail.com
17	Takeshi okamura	Team Leader	Nippon Koei	Okamura-tk@n-koei.jp
18	Yasushi Azuma	Telecommunication Expert	Nippon Koei	a3032@n-koei.co.jp
19	Gilbert Maiyo Chumo	Water Resources Engineer	Nippon Koei	gilchumo@gmail.com
20	Doreen Iluba	Office Admin	Nippon Koei	ilubadoreen@yahoo.com
21	Denis Masika	Hydrologist	Nippon Koei	dmasika@gmail.com
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... Eugene Ma...

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

Mute all

In this meeting (23)

GC Gilbert Chumo (Guest)

AD ABDI OMAR (Guest)

A azuma (ゲスト) (Guest)

D DOREEN (Guest)

Dr. Lee Baraza (Guest)

EA Eric Busiega

EM Eugene Mwandoe (Guest)

EM Eugene Mwandoe (Guest)

FM Faith Mbathi (Guest)

JT Jackline- Embu (Guest)

JN Jane Wairimu Njoroge (Guest)

JN Jared Otieno-WRA HQ (Guest)

JN Josiah Maina Waboyo

K KENNEDY OCHIENG

M Masika (Guest)

M Morgan Onyango

PM Patricia Musau (Guest)

PM reuben ngesa

Freeeam APBS

Appendix 11

**Report on Seminars on the Telemetry
Equipment and Mike Workbench and Mike
Zero Software (July 24 to 26, 2024)**

Report on Seminars on the Telemetry Equipment and Mike Workbench & Mike Zero Software

July 24-26, 2024, at Embu

JICA Experts Team

1. Dates: July 24 to 26, 2024
2. Venue: Water Resources Authority (WRA) Tana Basin Area Office in Embu
3. Participants: As per attached attendants lists

Following participants consists of Hydrologist, ICT/IT, commination expert and water resource expert from WRA H/Q, SROs of Embu, Kergoaya, Meru and Murang'a including JICA Experts Team.

July 24: 20 personnel

July 25: 19 personnel

July 26: 18 personnel

4. Schedule:

JICA Experts Team and some WRA staff have mobilized to Embu in the morning of June 24, 2024 for preparation of the training session.

Summary of the seminars and details of the programme is as per attached file.

JICA Experts Team and WRA H/Q staff have conducted seminars on the telemetry equipment in Kenya and in Japan. In addition, seminars on the Mike Workbench & Mike Zero Software have undertaken.

The sessions were done through presentation of the materials and hands-on installations of Mike Workbench and Mike Zero software by the participants. The presentations were aimed to give knowledge on the telemetry equipment, operation of Mike Workbench & Mike Zero Software and adoption to the water level gauging stations in the Pilot Study Area in tana river basin.

During the sessions, training of Mike Workbench & Mike Zero Software. First, the trainees have learned how to operate this application through the hands-on installation's software. Then they learned the basic operation, simulate the results of date measurement and analyze the hydrological models so on.

Photos of Training Session Activities

<July 24 - 26, 2024>

	
Presentation for Real Time Telemetric Equipment Data Acquisition and Management Capacity building by Mr. Josiah Maina, WRA: Knowledge Management Officer/I.C.T	Presentation for Real Time Telemetric Equipment Data Acquisition and Management Capacity building by Mr. Azuma, JICA Expert: Telecommunication/ Innovation of Technology
	
Presentation for Real Time Telemetric Equipment Data Acquisition and Management Capacity building by Mr. Eugen Mwandoe, JICA Expert: Communication Expert	Participants from WRA staff

5. Attachment:

- (1) Results of Seminars for Water Resources Real Time Telemetric Equipment Data Acquisition and Management Capacity Building held from July 24 to July 26, 2024, at Embu
- (2) Presentation Material
- (3) Attendants List

(1) Results of Seminars for Water Resources Real Time Telemetric Equipment Data Acquisition and Management Capacity Building held from July 24 to July 26, 2024, at Embu

Date: July 24 (Wed)

Session No.	Topic	Lecturer	Material	Issue and Concern
1	Installation of Mike Workbench & Mike Zero Software Study Database Data & modules	Mr. Josiah Maina	Software, Modules and Training material	Power point presentation of the installation process, database objects explores and grouping of data demonstrated. Hands-on installations of Mike Workbench and Mike Zero software was carried out by the participants. Similarly, DHI License administration exercises were also done and communication between Mike Workbench and Mike Zero established. The participants were concerned on this matter because the demo limits applicability of the software. Licenses were previously available but got damaged and plans to replace them are underway. However, WRA welcomes support from partners for purchase of more licenses.
2	Introduction to Mike Workbench Graphical User Interface: Database Connectivity	Mr. Josiah Maina	Mike Workbench Installation Manual	Hands-on installation of the postgres database and establishment of the same as well as its connectivity – “log in” to the Mike Workbench GUI conducted using the Database Utility Manager of

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				the software conducted. Emphasis was made to take note and safeguard passwords and port, otherwise data is lost. Participants followed up with hands-on exercise of database modules and explorer use and data manipulation and visualization in real time on pilot station discharge data. Some participants had to use the demo version of the software due to lack of adequate licenses.
3	Field Equipment Installation: SEBA and Data logger Communication	Mr. Rueben Ngessa	Installation of SEBA Telemetry	Power point presentation of existing real time telemetric equipment and network was presented. The sensors embedded in the SEDa equipment and key components described fully. Communication with the data logger is among key issues highlighted. The data logger still stores data even when the battery was lower than 11 Volts. Budgetary concerns for O&M of equipment is cause for lukewarm operation of the stations. Similarly, vandalism is rampant.
4	Discussions & Questions, Quality Control and Assurance; Maintenance, Missing data, Filling Data Gaps	All		Issues of equipment vandalism and how to address it was discussed at length. Support by stakeholder and local administration through sensitization was stated as the entry level for WRA to address vandalism. Regional and sub-regional staff were told to seek and show keen interest to capacity build on installation and O&M.

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JICA - Kenya Water Resources Advisors

Date: July 25 (Thu)

Session No.	Topic	Lecturer	Material	Issue and Concern
5	Telemetric Equipment in Japan – Best Practices	Mr. Yasushi AZUMA	Telemetry Related Systems MLIT 20240725	Telemetry and the related systems below operated by MLIT in Japan for the hydrological data were presented. - River Information System - Dam and weir management system - PLATEAU: PLATform for Advanced urban data and Urban planning - Telemetry equipment that is standardized by MLIT - C-band radar rainfall gauge - X-band radar Multi Parameter (MP) radar information network - CCTV (Closed Circuit Television) - Achievement of telemetry and X-band radar-Flood Forecasting and Warning System (FFFS) in other country (Japanese Grant) WRA has showed concern for CCTV system and vandalism against the equipment in Japan.
6	Introduction to Mike Hydro Schematic for Pilot Study Area Populating Mike Schematic, Transfer to Mike Workbench & Model Setup	Mr. Eugen Mwandoe MNYAMWEZI	References: Mike Zero and Mike Workbench Installation Manual & User Guide	Power point Step by Step procedure for development of Schematic presented; Hands-on development of Mike Hydro Basin Schematic for Pilot Study area (Sagana-Gura Sub-basin)

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JICA - Kenya Water Resources Advisors

			Training data for Sagana – Gura Sub-basin Training data for Koru – Soin Dam Design Watershed	Task was complemented using Koru – Sion Dam Watershed in LVS_ WRA which had complete datasets.
7	Time Series Manger – Data Entry Exercises, Time	Messrs. Eugen Mwandoe MNYAMWEZI and Josiah Maina	Copy of Koru – Soin Hydrological Report carried out by resource person	Task demonstrated using data the Koru – Sion Dam key station Nyando at RGS 1GD07 Too few Mike Software licenses limited hands-on application exercises WRA is addressing the issue
8	Practical Applications: Upper Tana Pilot Study DEM Schematization &	Messrs. Eugen Mwandoe MNYAMWEZI and Josiah Maina	Pilot Sub-basin DEM Raster data Format as an ASCII Sagana – Gura Watershed Format as UTM Zone 37S Koru – Soin Watershed DEM Raster data Formatted as UTM Zone 36S	Hands-on DEM catchment delineation of Koru-Soin and Sagana-Gura Watersheds using Mike Hydro

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(1) Results of Seminars held from July 24 to July 26_for Telemetering-2up

JICA - Kenya Water Resources Advisors

Date: July 26 (Fri)

Session No.	Topic	Lecturer	Material	Issue and Concern
9	Introduction to Scenario Manager and Time Series Manager Pilot Project Exercises & Simulations	Eugen Mwandoo MNYAMWEZI	As above	Activity demonstrated using Time Series data for Koru – Sion Dam key station Nyando at RGS 1GD07
10	Time Series Manager & Scenario Manager Pilot Project Exercises	Eugen Mwandoo MNYAMWEZI	N/A	Scenario Manager exercises not done due to a power blackout
11	Discussions & Building Scenarios for Pilot Study	All participants feedback and collective recommendations	N/A	Participants provided feedback on the training raising concerns on software licenses; Requested further support on Telemetry equipment installation, purchase for Drought and Flood Early Warning, installation, training and budget for O&M Concerns were raised about limited capacity to mitigate floods in Tana basin

Attendance: ATTENDANCE LIST 24TH-26TH JULY 2024 who are Hydrologist, ICT/IT, commination expert and water resource expert from WRA H/Q, SROs of Embu, Kerugoaya, Meru and Murang'a and JICA (5 personnel)

July 24: 20 personnel, July 25: 19 personnel and July 26: 18 personnel

Materials:

- Installation of Mike Workbench & Mike Zero (1)
- Installation of SEBA Telemetry
- Manual to Telemetry

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JICA - Kenya Water Resources Advisors

- Telemetric Training Program - WRA, Embu 24 _26thJuly2024 (1)
- Telemetry Maintenance and Troubleshooting
- Telemetry_Related_Systems_MLIT_20240724
- Kenya_MIKE_INFO_Handbook

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(1) Results of Seminars held from July 24 to July 26_for Telemetering-2up

Installation of Mike Workbench, Mike Zero Softwares and Database, Data & modules Josiah Maina -SKMO	System Introduction and Data Flow • WRA Real-time Data Acquisition System in implemented at WRA headquarters using the MIKE Workbench software. • The system is configured to Ingest hydrometeorological observations for a variety of ground-based observation networks across Kenya.
The objectives of WRA Real-time Data Acquisition System is as follows: • Collect, process, and provide access to the WRA meteorological, flow and water levels data from as many ground-based observations networks as possible • Monitor the data acquisition process and report on data sources (stations) that do not report • Provide a means to WRA officers to visualize, quality control and edit data • Forward ingested data for use by the WRA Real-time Data Acquisition System	Real-time Data Acquisition System Processes <pre> graph TD A([Telemetric Station (Existing and new WRA Telemetric Stations)]) --> B[Scripts to read and process data from different sources (in xml, text, csv and JSON formats) and store it as a timeseries in MIKE Workbench database.] B --> C[/Station based timeseries for (Water level, meteorological data)/] C --> D[Web based interface to display timeseries, stations map and documents and spreadsheets associated with each station object. MIKE INFO Web is used. (41.79.11.230)] D --> E[Send daily summary email of the list of data imported into the database and the list of stations that didn't transmit data to the system administrators at WRA.] </pre>
Installation Requirements ➤ Windows 64bit computer with at least 8GB RAM for Ease of running the Application ➤ PostgreSQL 11 and above ➤ DHI License management included in Mike Operations ➤ .NET Framework 4.5	Installation(Practicals) 1. Run setup.exe and installed required Modules Once installation is done and you require to enable Lan access 2. open PG_HBA_CONF and Edit to reflect #Host ALL ALL 0.0.0.0\0

Configurations

- Configure the firewall (inbound) and allow the port 5432?
- Configure the DHI License (Internet/Dongle)
- Configure the Data Manager utility (PostgreSQL) and Create a New Training Database

END

INSTALLATION OF TELEMETRIC EQUIPMENT

- ❑ Overview of Civil Works for the Instruments
- ❑ Logger House
- ❑ Rainfall, Temperature/Humidity Sensors
- ❑ Water Level Sensor

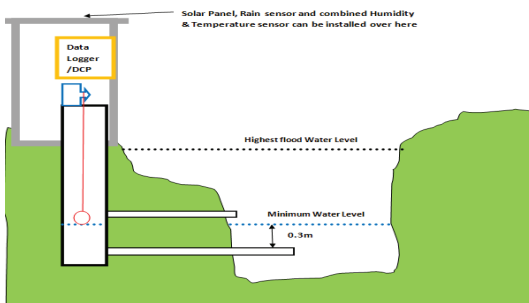
Overview of Civil Works for the Instruments

- ❑ The civil work structure will depend on the type of water level sensor to be used:
- ❑ Two types of WL sensors are:
 - Float operated sensor (shaft encoder)
 - Pressure sensor

Sensor	Appearance	Application	Remarks
Shaft Encoder (level sense)		Based on the float mechanism principle which consist of a float and counter weight(floating on the surface water level) and digital surface water level logger/digital	Installed inside a stilling well and is good for flush floods
Pressure Sensor		The sensor is installed below the water surface level and records the hydrostatic pressure	Does not require a stilling well and is simple to install

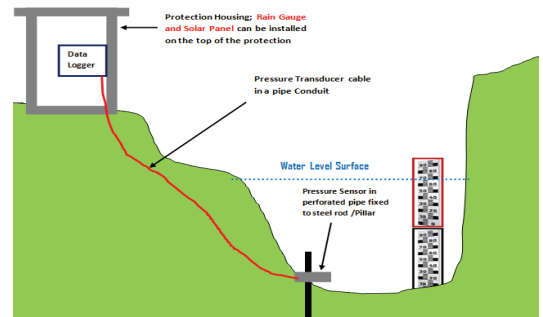
Structure for Shaft Encoder

Stilling well constructed at the River bank



Structure for Pressure Transducer

Pressure transducer with Protection Housing



Logger House

- ❑ The following precautions should be taken when citing a logger house(and generally the telemetric station):
 - There should be good coverage of mobile network
 - The site should be easily accessible
 - The logger house should be located reasonably away from the highest flood mark of the river to avoid inundation
 - The right materials(concrete) should be used so that the house remains strong

Specifications for the Logger House



- 2m by 2m floor, at least 2.4m high. Plain concrete floor slab 1:2:4 mix on firm base
- Roof slab to be 2.4m square. Plain concrete slab 1:2:4 mix, 150mm thick
- 230mm thick wall built with cement/sand motor (1:3 mix)
- Walls to be plastered both inside and outside with 1:4 mix of cement/sand motor
- Heavy duty steel door with provision for appropriate lock system
- Ventillation Air bricks of approximately 900mm by 900mm
- Walls to be painted white (outside and inside) while the door and fascia skirting to be dutch blue

Installation of Rainfall, Temperature/Humidity Sensors



Tipping bucket rain gauge



Temperature/Humidity Sensor

- The sensors are installed on the roof of the logger house
- The stand for the raingauge is provided with the equipment
- Temperature/Humidity sensor stand can be fabricated locally (Jua kali workshop) and painted aluminum
- Where both sensors are to be installed, an arm for Temperature/Humidity sensor can be fabricated on the rain gauge stand
- The sensors are fixed on the roof slab using expansible wall bolts



Installation of Water Level Sensor

- The float and counter weight of the pressure sensor are installed inside a stilling well
- Pressure transducer can be installed inside a stilling well or inside a 1-2inch conduit buried on the ground from the logger house to the river
 - A perforated steel pipe is connected to the conduit to house the transducer
 - The pipe can be welded on the first gauge (post/strut) or fixed inside the river using concrete base

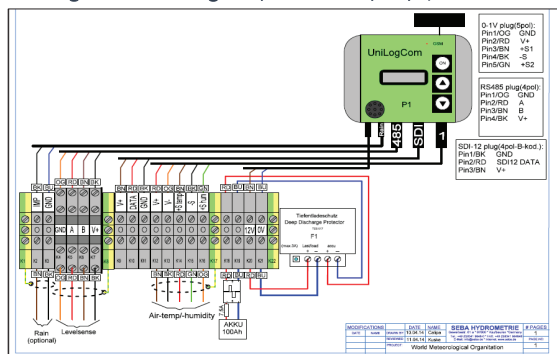


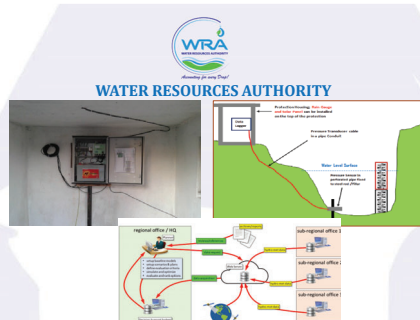
Installation of Data logger/DCP

- The data logger is fixed on the logger house wall using expansible wall bolts
 - A support should be provided because of the heavy battery
- The sensor cables are then fixed to the Data logger according to the wiring plan
- The parameters are configured and the modem set and activated using the appropriate softwares



Wiring Plan for UnilogCom, LevelSense, RG, T/H sensors





Real Time Data Transmission, viewing and Archiving Manual to Telemetry

Presented by: Reuben Ngessa

HISTORY OF WATER RESOURCE MONITORING IN KENYA

Period	Agency Responsible	Location of monitoring stations	Type of Data Collected
Early 1900s	White settlers	Along the Kenya – Uganda Railway	Mostly Rainfall data
Mid 1924 – Early 1960s	White Settlers	“White” Highlands and along all Major Rivers	Rainfall, Water level
After 1964	Ministry in Charge of Water Kenya Meteorological Department	All the Catchment Areas in Kenya	Water level, Climatic
		All the Catchment Areas in Kenya	Climatic
2007	Water Resources Authority	All the Catchment Areas in Kenya	Water level, Climatic



Surface Water Monitoring Stations

Region	Category				Total
	National	MU	IMU	Special	
LVNCA	5	6	10	7	28
LVSCA	5	14	26	2	47
RVCA	4	8	14	0	26
ACA	3	4	21	3	31
TCA	1	24	15	15	52
ENNCA	1	5	33	1	40
Total	22	48	122	31	223

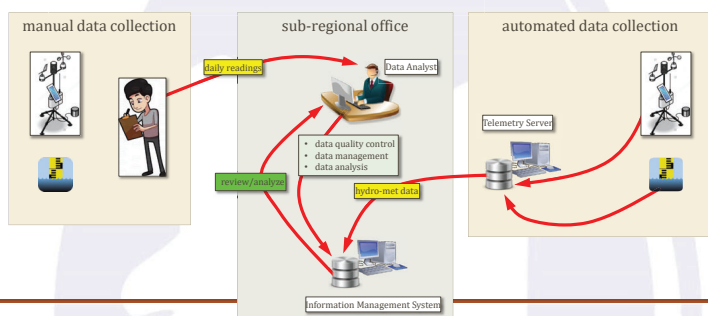
Optimum Number is 362

118 automated with data loggers and telemetry
 - 63 water level
 - 55 weather
 - WRA also monitors Ground Water (142 stns rationalized) and Water Quality (658 stns rationalized)

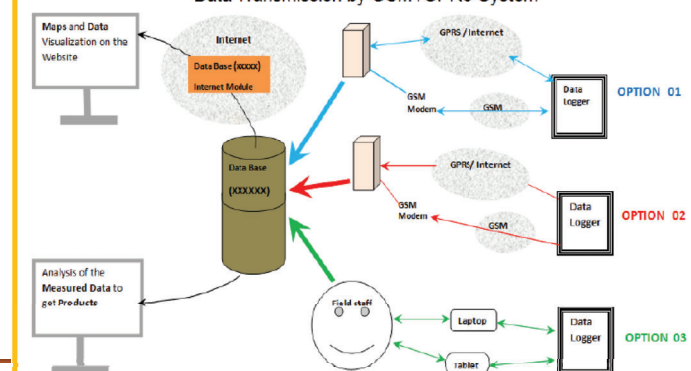
Manual Data Collection To Telemetry



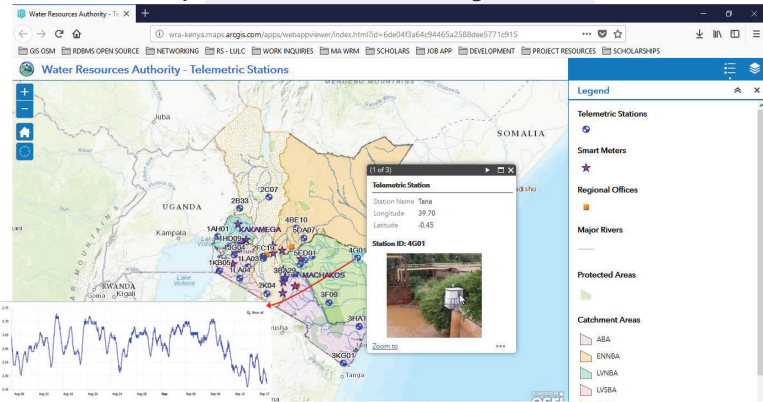
DATA COLLECTION, QC & ANALYSIS



Data Transmission by GSM /GPRS System

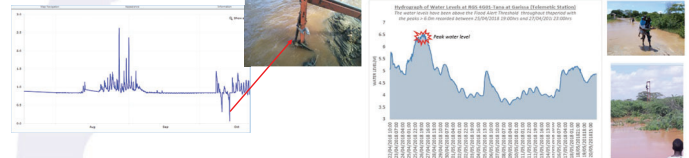


Sample Telemetric Data Through WRA WRIS



Telemetric Data Use

- Flood Early Warning
- Reserve Violation
- Monitoring the Status of the Station
- Monitoring Activities in the River

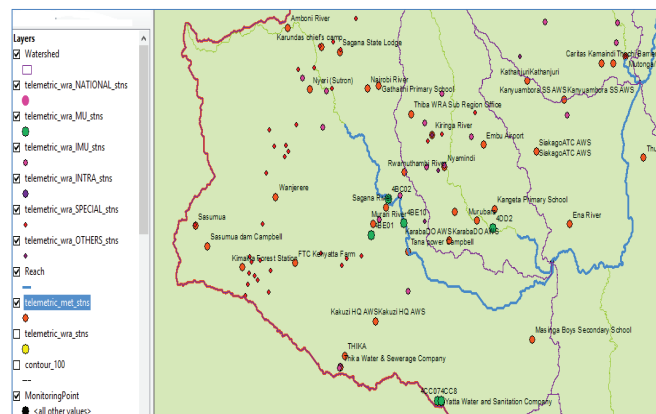


Capacity Building for WRA Staff

Pre-processing data; historical & telemetric data
Framework for Real Time WAP and;
Early Warning for Flood & Drought Mitigation

Presentation by Eugen Mwandoo Mnyamwezi
IICA WRA Advisor Team

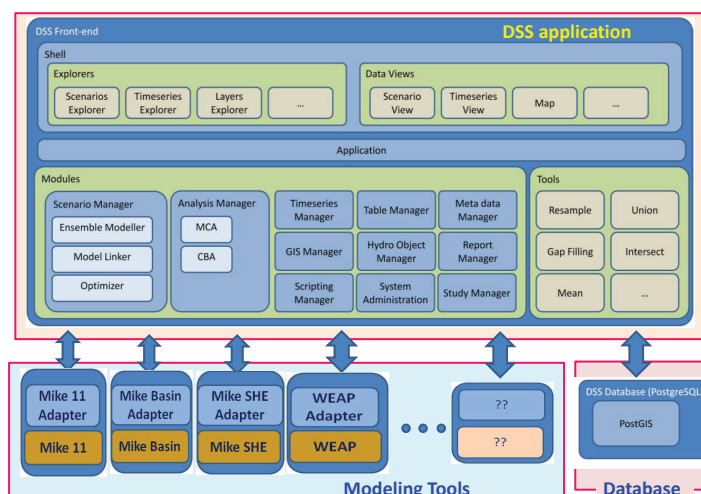
Sample Distribution of Stations Upper Tana Pilot Sub-basin



Mike Suite Software Approach to Data Pre-processing GIS enabled and Time Series Managers

Summary Information for Decision on Water Allocation at Management Unit Level and Mike Workbench Node Junction

Mike Workbench & DSS - Software Layout and Components



Real Time Data Analysis for Information Products Generation and Interpretation to Inform WAP and Early Warning for Flood & Drought Mitigation

- DEM analysis for pilot sub-basins delineate sub-basin shapefiles, characteristics and basic parameters
- Respective Mike Workbench Managers
 - Database Manager linked to real time Telemetric station to download observed data
 - GIS Manager
 - Time Series Manager with historical data for real time updating
 - Indicators Manager (Prescribed threshold for O&M and Development etc
 - Script Manager
 - Spreadsheet Manager
 - Scenario Manager
- Respective Mike Zero Schematic for updating new developments in sub-basins
 - Updating Time Series
 - Updating new projects and stations
 - Updating new abstractions
 - Updating operational changes or enhancements

Establishing a Framework for Real time Water Balance at Sub-basin Level with Telemetric data to support WAP

Application Models & Tools for WAP and F&D Early Warning
including Climate Change impacts on WR:

WEAP & Mike Zero Adapter allows both Model Linking:

- ❑ WEAP uses summary data
- ❑ Mike Integrates Hydrodynamic Models – basin wide

- Updating abstraction water use permits in Real Time
- Association of water use /abstraction data in sub-basin
- Associating telemetric station flow time series in sub-basins
- Associating telemetric station rainfall time series in sub-basins

Purpose of data pre-processing data

- DATA QC & QA
- Representativeness of reality [Comparative Analysis – graphs, visualization, regression/correlation]
- Identify gaps [Mike Workbench - graphical plots, visualization tools...]
- Infilling missing data: several approaches [Participant feedback]
 - Where are the missing values/gaps [Coverage graph]
 - How many [Time series chart/Table]
 - How to fill gaps[Time interval; daily, monthly, seasonal, annual...]
- MIKE WORKBENCH TOOLS
 - Time Series Manager Tools [RGS 4BC02 Node data- Input/Output data]
 - **INFLOW & OUTFLOWS AT NODE LEVEL**
 - Discuss Node objects [Input and Output]
 - For each Node respective Inflows and Outflows
 - Water demand Deficit
 - Net flow to Node etc
 - **Duration Curve Analysis & Comparing Two or Time Series**
- Simulation Results displayed at Respective
 - **NODES AS OUTFLOW**

Framework for Telemetric Station for Water Allocation Planning (WAP) at Pilot Sub-basins

Data Requirements

- GIS Applications:
- DEM
- Flow stations shape files and flow time series data (daily, hourly, monthly etc)
- Rainfall station shape files and rainfall depth time series data (daily, hourly, monthly etc)
- Evaporation time series data
- Abstraction time series

Outputs & Outcomes

- Water balance at respective GIS generated stream nodes
- Water balance at specific sites for WAP
- Updated water status in the overall basin for all users and in each river reach
- Real time allocation modification at any channel point
- Updated basin-wide water balance status via scenario and simulation for decision and negotiation of water use and tradeoff
- Timely WR Status Reports for informed WAP
- Generated Information Products for Flood and Drought Early Warning

WRA: Management Unit Water Balance Analysis For Water Allocation Assessment 2005/6

Hydrological Unit	Management Unit	Area km ²	Q	Res.	I+D	LS	FP	Irr.	Trfcr	Use	Rest	Qmin
4AA-AD	Sagana-Gura	2,073	18.37	1.14	0.37	0.03	0.19	10.42	0.00	12.15	6.22	3.68
4BA-BF	Lower Sagana	2,723	57.61	4.71	0.50	0.06	0.04	49.55	0.00	54.85	2.76	25.73

Hydrological Unit	Management Unit	Area km ²	SW	GW	Unable returnflow		Total yield
					Irr	ID	
4AA-AD	Sagana-Gura	2,073	17.23	0.01	4.17	0.29	22
4BA-BF	Lower Sagana	2,723	52.90	0.05	19.82	0.40	73

Hydrological Unit	Management Unit	ID	LS	FP	Irr.	Others	Local requirement
4AA-AD	Sagana-Gura	0.37	0.03	0.19	10.42	0.00	11.01
4BA-BF	Lower Sagana	0.50	0.06	0.04	49.55	1.00	51.14

Hydrological Unit	Management Unit	Local yield	Transfers	Local requirements		Balance		Potential for development
				with Irr.	without Irr.	with Irr.	without Irr.	
4AA-AD	Sagana-Gura	21.70	0.00	11.01	0.60	10.69	21.11	
4BA-BF	Lower Sagana	73.17	0.00	51.14	1.59	22.03	71.57	4BB

Hydrological Unit	Management Unit	Area km ²	Yield	Requirement	Balance
4AA-AD	Sagana-Gura	2073	8.86	0.29	10.18
4BA-BF	Lower Sagana	2723	21.16	0.59	26.28

Correlation & Regression of Daily flows for Pilot Sub-basins

Regression equations between sub-basins daily flows Tana 4BE02, Tana Sagana 4BC02 and Tana Rukanga 4BE10

Name: SAGANA	Name: TANA SAGANA	Name: TANA SAGANA	Name: TANA RUKANGA		
MaFocus: [01/04/1940,01/06/2006]	MaFocus: [01/04/1940,01/06/2006]	MaFocus: [01/04/1940,01/06/2006]	MaFocus: [01/04/1940,01/06/2006]		
Correlation coefficient:	0.625	Correlation coefficient:	0.789		
Covariance:	304.297	Covariance:	1413.916		
Number of valid value pairs:	393	Number of valid value pairs:	4163		
For the valid value pairs of these series:		For the valid value pairs of these series:			
	X Series	Y Series			
Minimum:	1.02	5.78	Minimum:	5.10	5.75
Mean:	10.76	33.04	Mean:	31.37	95.05
Maximum:	144.51	274.68	Maximum:	219.50	550.44
Median:	7.00	22.07	Median:	24.15	75.15
Standard deviation:	12.13	29.92	Standard deviation:	29.12	101.57
Axis intercept:	0.4076	11.5237	Axis intercept:	14.0011	2.9304
Regression coefficient:	0.3634	0.0000	Regression coefficient:	0.2390	1.0706
$\hat{Y} = 0.4076 + 0.3634 \cdot X$	calculate from		$\hat{Y} = 14.0011 + 0.2390 \cdot X$	calculate from	
$\hat{Y} = 11.5237 + 0.0000 \cdot X$	Comment		$\hat{Y} = 2.9304 + 1.0706 \cdot X$	Comment	

Maragua 4BE01 Versus Tana Rukanga 4BE10

Name: MARAGUA	Name: TANA	Name: TANA	Name: TANA RUKANGA		
MaFocus: [01/11/1946,25/02/2003]	MaFocus: [01/11/1950,31/07/1981]	MaFocus: [01/11/1950,31/07/1981]	MaFocus: [01/05/1979,29/01/1987]		
Correlation coefficient:	0.804	Correlation coefficient:	0.800		
Covariance:	1523.980	Covariance:	3040.042		
Number of valid value pairs:	7553	Number of valid value pairs:	950		
For the valid value pairs of these series:		For the valid value pairs of these series:			
	X Series	Y Series			
Minimum:	0.20	4.57	Minimum:	15.96	7.34
Mean:	12.09	88.00	Mean:	139.15	20.79
Maximum:	335.39	1036.84	Maximum:	960.28	98.64
Median:	5.05	52.44	Median:	90.41	17.00
Standard deviation:	15.41	97.59	Standard deviation:	146.15	20.00
Axis intercept:	-1.9903	39.1387	Axis intercept:	9.7136	6.9557
Regression coefficient:	0.1600	4.0444	Regression coefficient:	4.4975	0.1423
$\hat{X} = 1.9902 + 0.1600 \cdot Y$	calculate from		$\hat{X} = 9.7135 + 4.4975 \cdot Y$	calculate from	
$\hat{Y} = 20.1381 + 0.0444 \cdot X$	Comment		$\hat{Y} = 6.9557 + 0.1423 \cdot X$	Comment	

Data acquisition

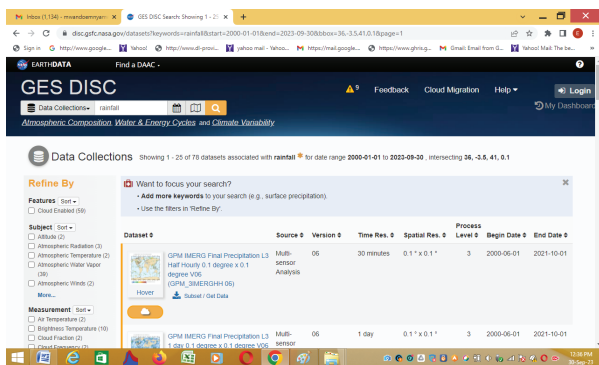
- Stream flow gauging with an ADCP



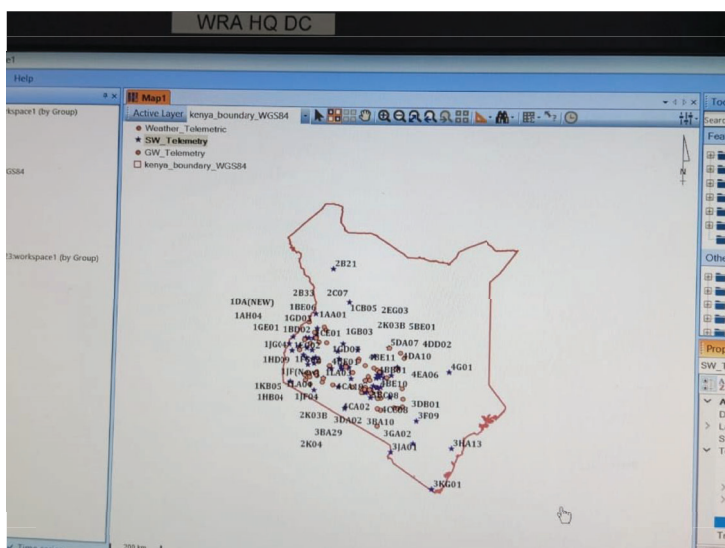
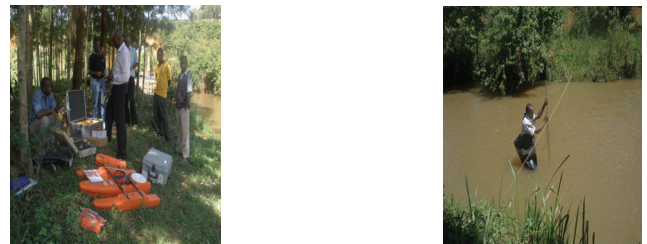
Telemetric Automatic Weather Station (AWS) Satellite Derived Rainfall Data downloads



Downloading Global datasets



Discharge Measurements: ADCP and Current Meter flow meters

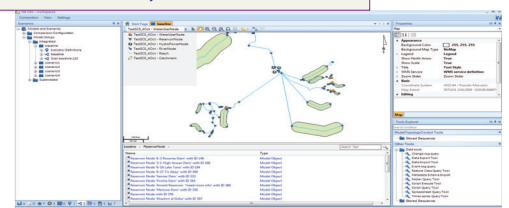


Modeling tools

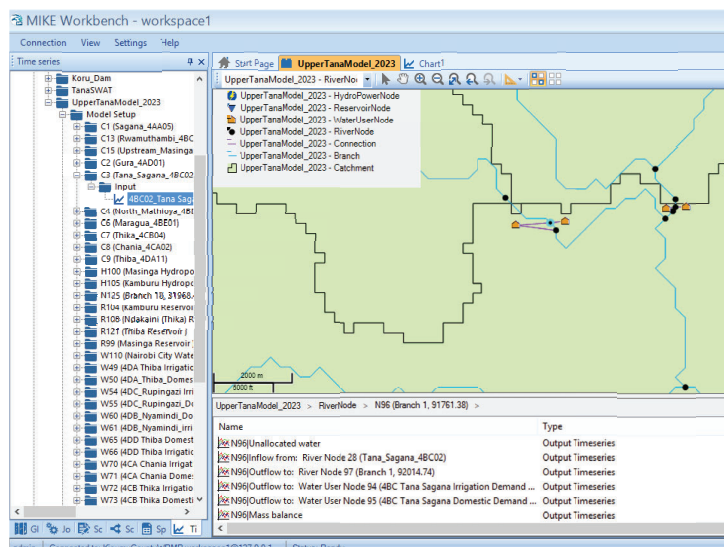
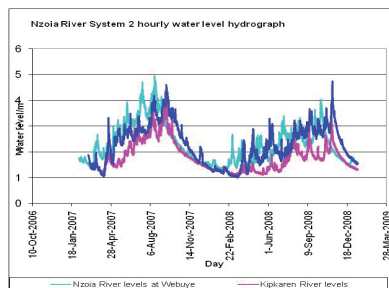
Mike-Basin/Hydro: Water budget and allocation Model:

- Water allocation scenario modeling
- Reservoir/hydropower operation
- Hydrological modeling (rainfall-runoff)
- Irrigation demand and yield assessment
- In-stream nutrient modeling

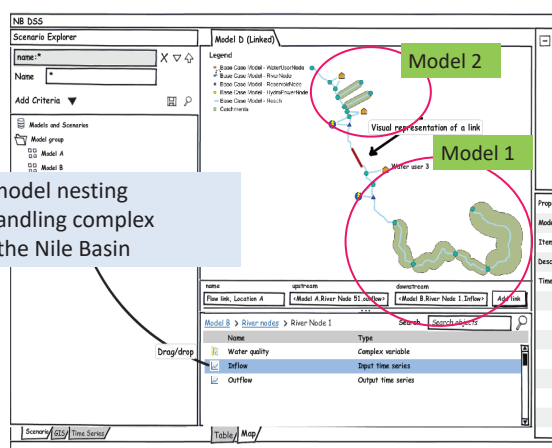
Mike-11: Hydrodynamic model (1-dimensional) Rainfall-runoff models: Mike-SHE, NAM



Water level variations between two stations (estimating time of travel of a flood wave between stations)

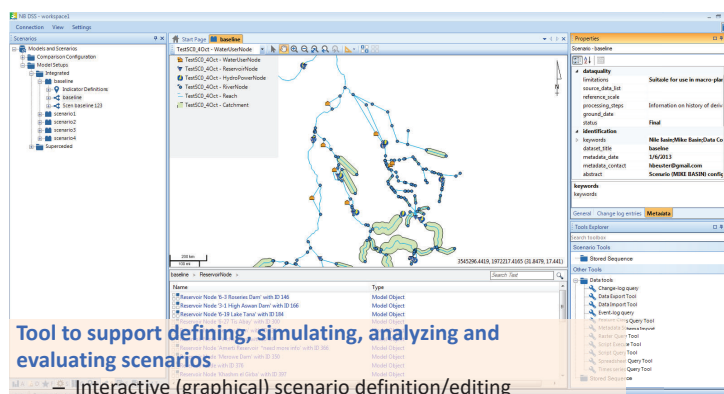


Model linking/nesting tool



- Facilitates model nesting
- Useful for handling complex hydrology of the Nile Basin

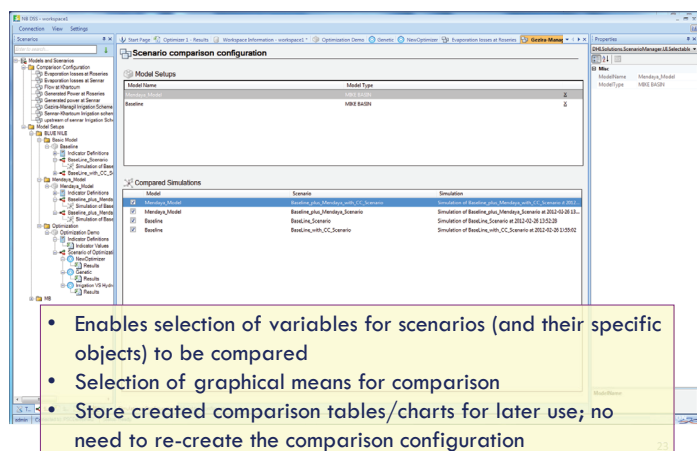
Scenario management



Tool to support defining, simulating, analyzing and evaluating scenarios

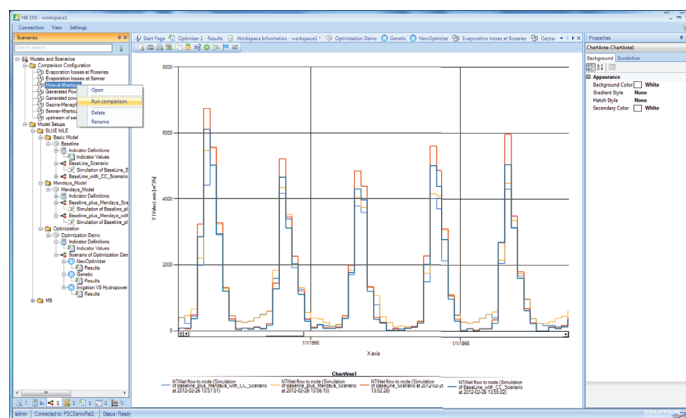
- Interactive (graphical) scenario definition/editing
- Simple visualization of scenarios
- Scenario simulation
- Scenario Comparison

Scenario Comparison tool

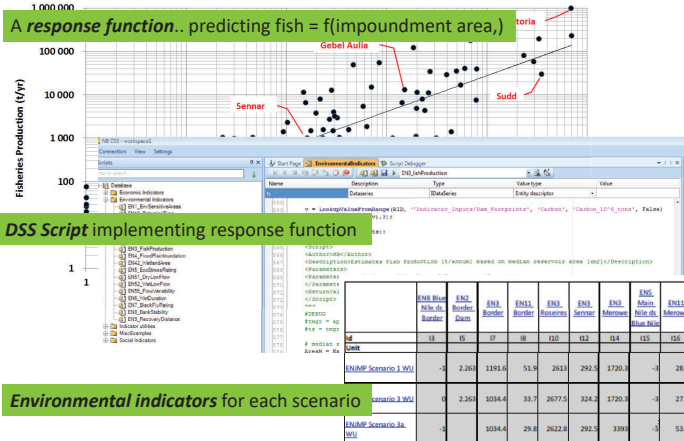


- Enables selection of variables for scenarios (and their specific objects) to be compared
- Selection of graphical means for comparison
- Store created comparison tables/charts for later use; no need to re-create the comparison configuration

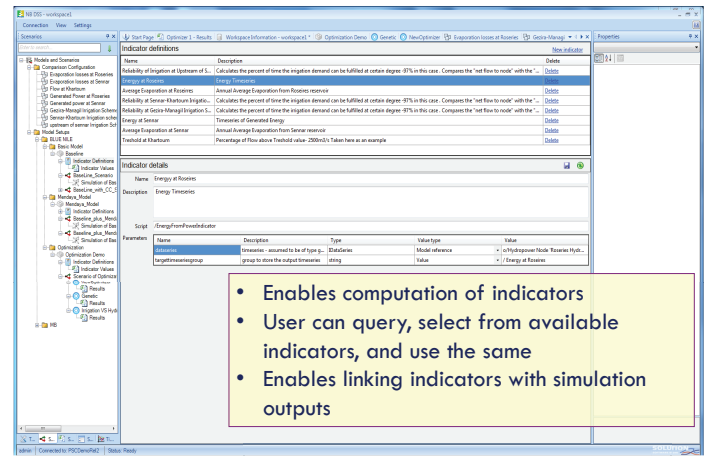
Scenario Comparison tool – Example



Integrating environmental objectives in decision making



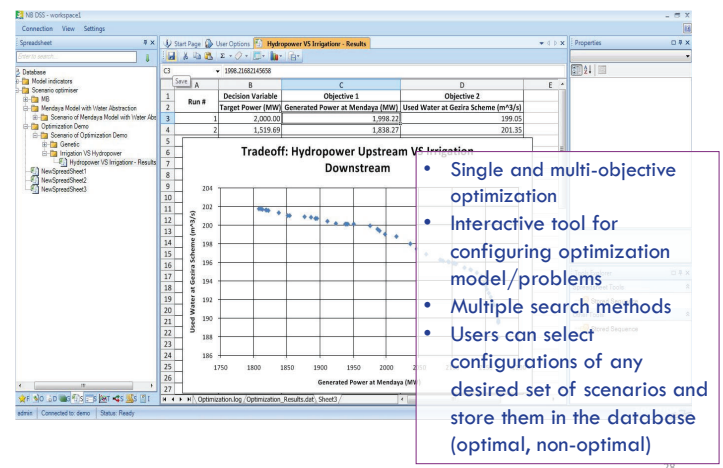
Indicator Manager



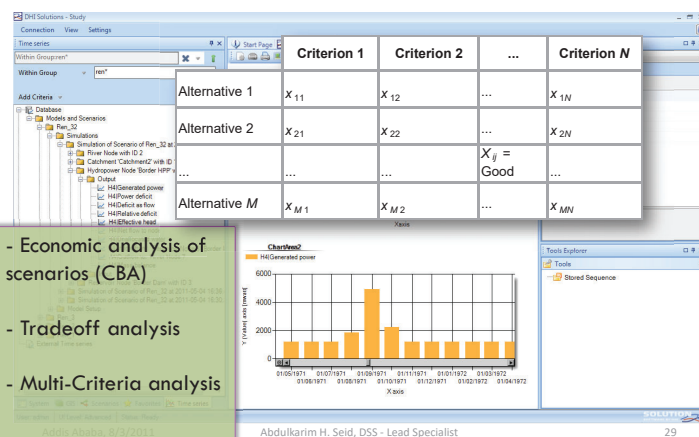
Indicator Definitions - sample

Environmental					
Category	ID	Name	Units	Description	Units
Footprint Areas	EN1	Environmentally Sensitive Area	km2	Extent of Environmentally Sensitive Area within dam / irrigation scheme / canal footprint	km2
	EN1_1	Environmentally Sensitive rating	Index	Size of environmentally sensitive area / IUCN category in footprint	number
	EN1_2	al hotspot	Index	Wetlands of international importance (Ramsar Sites) and Important Bird Areas (IBAs) that fall outside of protected areas, but within primary impact zones, are classified equivalent to IUCN Categories I & II (i.e. rating 5).	number
Social					
Category	ID	Name	Units	Description	Units
Water Availability	SO1	Change in availability of water for riparian users: domestic consumption, subsistence agriculture and livestock	% Change from Baseline	Dry season low flow: Median flow during lowest consecutive 3 months in dry season	
	SO2	Susceptibility of irrigation scheme areas to malaria based on WHO malaria incidence map for Africa	Mean malaria endemicity of population within irrigation area footprint (%)	Malaria incidence map of Africa AND location of new irrigation schemes	
	SO3	Prevalence of diseases resulting from pest species	Index	Proxy: EN7 - Abundance of Pest blackflies (refer to Table 5-4)	
Community Health and Safety	SO4	Water pollution d/s major urban areas	Time of decay (h) to acceptable coliform concentrations	Defined load factors; Constituent loads/concentrations in river; biological decay relationships	
	SO5	No households within the 100 year flood	% Change from	100 year flood envelope	

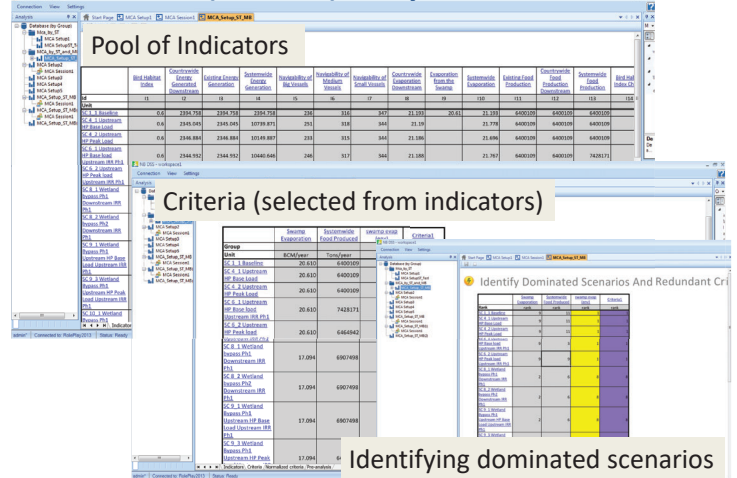
Multi-objective Optimization



Decision making tools



Multi-criteria (Decision) Analysis Tool



Multi-criteria (Decision) Analysis Tool

Incorporating stakeholder preferences

The screenshot displays the 'Define Criteria Weights' window of the Multi-criteria (Decision) Analysis Tool. It shows a list of criteria on the left and a table for defining their weights. The 'Normalized Weights Table' is also visible, showing the calculated weights for each criterion.

Define Criteria Weights

Criteria	Rank
Swamp Evaporation	1
Systemwide Food Produced	2
Swamp Crop Yield	3

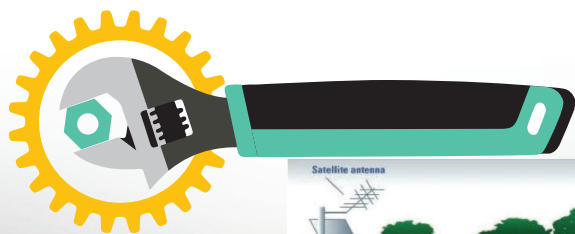
Normalized Weights Table

Criteria	Weights (0-100)
Swamp Evaporation	33.33
Systemwide Food Produced	33.33
Swamp Crop Yield	33.33
Sum of weights (must be 100)	100

Review scenario ranking matrix

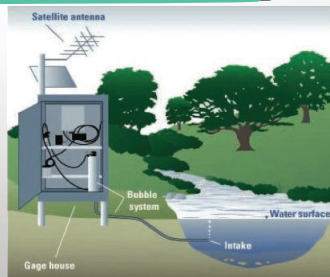
Scenario	Swamp Evaporation	Systemwide Food Produced	Swamp Crop Yield
Scenario 1	1	1	1
Scenario 2	2	2	2
Scenario 3	3	3	3
Scenario 4	4	4	4
Scenario 5	5	5	5
Scenario 6	6	6	6
Scenario 7	7	7	7
Scenario 8	8	8	8
Scenario 9	9	9	9
Scenario 10	10	10	10
Scenario 11	11	11	11
Scenario 12	12	12	12
Scenario 13	13	13	13
Scenario 14	14	14	14
Scenario 15	15	15	15
Scenario 16	16	16	16
Scenario 17	17	17	17
Scenario 18	18	18	18
Scenario 19	19	19	19
Scenario 20	20	20	20
Scenario 21	21	21	21
Scenario 22	22	22	22
Scenario 23	23	23	23
Scenario 24	24	24	24
Scenario 25	25	25	25
Scenario 26	26	26	26
Scenario 27	27	27	27
Scenario 28	28	28	28
Scenario 29	29	29	29
Scenario 30	30	30	30
Scenario 31	31	31	31
Scenario 32	32	32	32
Scenario 33	33	33	33
Scenario 34	34	34	34
Scenario 35	35	35	35
Scenario 36	36	36	36
Scenario 37	37	37	37
Scenario 38	38	38	38
Scenario 39	39	39	39
Scenario 40	40	40	40
Scenario 41	41	41	41
Scenario 42	42	42	42
Scenario 43	43	43	43
Scenario 44	44	44	44
Scenario 45	45	45	45
Scenario 46	46	46	46
Scenario 47	47	47	47
Scenario 48	48	48	48
Scenario 49	49	49	49
Scenario 50	50	50	50
Scenario 51	51	51	51
Scenario 52	52	52	52
Scenario 53	53	53	53
Scenario 54	54	54	54
Scenario 55	55	55	55
Scenario 56	56	56	56
Scenario 57	57	57	57
Scenario 58	58	58	58
Scenario 59	59	59	59
Scenario 60	60	60	60
Scenario 61	61	61	61
Scenario 62	62	62	62
Scenario 63	63	63	63
Scenario 64	64	64	64
Scenario 65	65	65	65
Scenario 66	66	66	66
Scenario 67	67	67	67
Scenario 68	68	68	68
Scenario 69	69	69	69
Scenario 70	70	70	70
Scenario 71	71	71	71
Scenario 72	72	72	72
Scenario 73	73	73	73
Scenario 74	74	74	74
Scenario 75	75	75	75
Scenario 76	76	76	76
Scenario 77	77	77	77
Scenario 78	78	78	78
Scenario 79	79	79	79
Scenario 80	80	80	80
Scenario 81	81	81	81
Scenario 82	82	82	82
Scenario 83	83	83	83
Scenario 84	84	84	84
Scenario 85	85	85	85
Scenario 86	86	86	86
Scenario 87	87	87	87
Scenario 88	88	88	88
Scenario 89	89	89	89
Scenario 90	90	90	90
Scenario 91	91	91	91
Scenario 92	92	92	92
Scenario 93	93	93	93
Scenario 94	94	94	94
Scenario 95	95	95	95
Scenario 96	96	96	96
Scenario 97	97	97	97
Scenario 98	98	98	98
Scenario 99	99	99	99
Scenario 100	100	100	100

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Telemetry Stations Maintenance and Trouble Shooting

By Reuben Ngessa



Agenda

- 01 Telemetry Stations Overview**
Set up of data communication devices, description of Telemetric System and Protocol.
- 02 Technical Overview**
Types of sensors (shaft Encoders, pressure, radar, care and handling of sensors, data collection platform and other accessories)
- 03 Preventative Maintenance**
Preventative maintenance, field checks and Calibration Methods
- 04 Troubleshooting**
Common problems and troubleshooting techniques

Modern Hydrometric Station



	Digital Sensors
	Remote data transmission
	More Precision
	More Compact
	More Durable

Types of Telemetry Stations



Aviation



Flow Gauging



Met Masts



General AWS

Components



- Power
- Communication
- Data Storage and Analysis
- Logger and Sensors

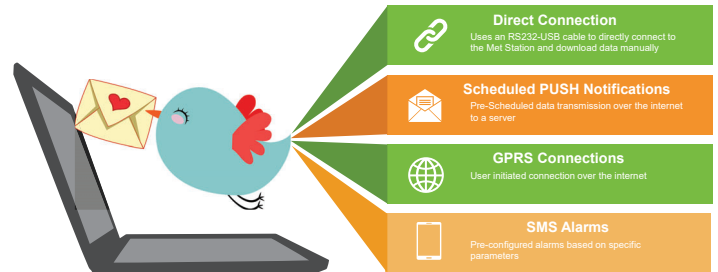
Sensors and Loggers



Power Unit



Communication



Maintenance

- Enclosure** > Ensure that enclosure is closed and sealed from humidity and dust
- Power** > Clean Solar Panels, monitor voltage levels to detect faulty battery
- Sensors** > Monitor debris flow to ensure sensors are not destroyed.
- Accuracy** > Significant deviations should be reported for sensor calibration or replacement



Common Problems

And troubleshooting techniques

SEBA UnilogCom OVERVIEW



SEBA UnilogCom OVERVIEW

Flash frequency of the Low Power LED:

Permanent light	LED always on	Power supply is not sufficient for modem operation
-----------------	---------------	--

Flash frequency of the NETWORK LED:

Permanent light	LED always on	- The modem is switched on, but not yet registered in the network - Registration procedure in progress - No network available - No SIM card inserted - SIM card is corroded → clean it
Flashing slowly	LED on for 200 ms, LED off for 2 s	Modem is active and successfully registered in the network.
Flashing quickly	LED on for 200 ms, LED off for 600 ms	Modem is active, registered in the network and data transmission is in progress
Flashing 3 times	LED flashes from start	PIN lock of the SIM card is active: Deactivate the PIN lock of the SIM card!

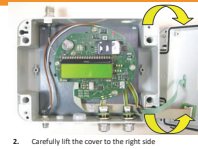
Flash frequency of the MODEM (Info) LED:

Permanent light	LED always on	Data transmission is in progress
Flashing twice	LED flashes once within 2s	Modem has been activated via the user interface
Flashing quickly	LED flashes twice within 2s	Modem has been activated by the data logger

Sim Card



1. Open the plastic cover on both sides and loosen all four screws



2. Carefully lift the cover to the right side



3. Release the SIM card holder



5. Press the SIM card holder down and push the fastener back in place



6. Put the cover back on, tighten the screws and close the device



4. Insert or remove the SIM card as illustrated

POWER SUPPLY

A

Modem turnoff threshold:

When falling below 11.0 V, the modem will be turned off. All functions related to telemetric data transmission are disabled!

B

Data logging turnoff threshold

When falling below 10.5 V, data logging of all channels will be stopped

C

Warning threshold

When exceeding 11.8 V, data logging will be started again, in case it has been stopped by the data logging turnoff threshold before.



Warning

Do not connect the device directly to 110 VAC or 230 VAC!



Important notice

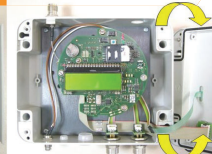
UnilogCom 3G/4G has to be supplied by an external power source with 12 VDC. The battery voltage is monitored on the internal channel no. 32 of UnilogCom 3G/4G.

The supply voltage always has to be over 10.5 V, otherwise data recording will be stopped.

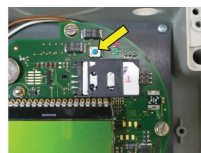
Resetting the Modem



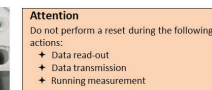
1. Open the plastic cover on both sides and loosen all four screws



2. Carefully lift the cover to the right side



3. Press the reset button.



Attention

Do not perform a reset during the following actions:

- Data read-out
- Data transmission
- Running measurement

Important notice

In case of failure (e.g. data logger does not respond) you can restart the device by doing a reset. By resetting the system, data and settings will not get lost.

Attention

Working on the open circuit board can cause overvoltage damage (ESD)

- Before touching, conduct possible body voltage by touching a big metallic object.
- Avoid direct contact to the circuit board and its components.
- Make sure that no humidity, dust or other foreign objects get into the device.

SIGNAL QUALITY

Classification of the signal quality

Signal quality	Meaning	
0	No reception	
1-8	Weak reception	Communication only in exceptional cases
9-15	Moderate reception	Communication not always possible
16-31	Good reception	Communication is possible

Classification of the GSM / 2G/3G/4G state

Value	Meaning
2,0	Not connected
2,1	Connected successfully
2,2	Search is running
2,3	Connection to network declined
2,4	Unknown state
2,5	Connected successfully (Roaming)
2,6	Only SMS
2,7	Only SMS (Roaming)



Common Problems



Troubleshooting

Error message "Com port already in use" when connecting

First make sure that you use the correct COM port. If that is the case, check if the COM port is already used by another application. If so, you have to end this application before it is possible to establish a connection to the modem with SEBA Modem Configurator.

Error message "The Device is not connected or out of order"

Make sure the interface cable is properly connected to the modem and it does not have any visible damages.

- Check if the device is sufficiently supplied with power so that the modem can be activated in general.
- Check with software SEBAConfig if the modem has been deactivated permanently. If so, activate the modem according to the present configuration (modems of battery operated systems should not be in continuous operation).

The modem connects to the wrong network

- Indicator: In the register "Device Info" in line 6 (connected to provider: xx) there is another provider than set in line 9. Especially in areas which are close to borders this may cause high costs if the modem connects to a foreign network.
- The modem connects to the network of the set provider if there is a sufficient signal quality of the provider for the functions enabled by the SIM card within this cell. You can use a smartphone for identification, however this does not always provide clear information since it can also use LTE network.
- Where appropriate, it is reasonable to use a SIM card of another provider or even a foreign provider.





Common Problems Troubleshooting



2G/3G/4G does not work

If the network basically works on-site, the following trouble-shooting might be useful:
Connect to the modem and check the following items in the register "Device info" in this order:

1. Line 4 (PIN): Does it show "ready"? Otherwise, deactivate the PIN
2. Line 5 (Signal/Error ratio): Is there a signal between 10 and 32, is the error ration "0"? Otherwise check the antenna or think about an extra antenna for better reception.
3. Line 6 (Provider): Is there a provider? Possibly there is no reception with the required network characteristics.
4. Line 7 (GSM/Mobile data State): Values 2,1,2,1? Otherwise open the register "Connection", check the box and transfer the settings to the modem one more time.
5. Line 8 (IP): Here has to be a value in the format XXX.XXX.XXX.XXX, not "0".
6. This value is received from the provider. Is there no IP address, it is likely that the SIM card is not activated
7. for 2G/3G/4G.
8. Line 11 (GGS Info): As soon as the modem receives an IP address, it tries to log in to GGS. If this was successful – this can take up to 30 seconds – the GGS returns a "Keepalive". If the state remains "not connected", it is likely that the settings for the GGS are wrong.



Important notice

When checking the system, click "Refresh modem status" frequently.
The status overview does not refresh automatically.



Important notice

The enabled functions of the SIM card are not saved on the SIM card but at your provider. Write down all the details of your SIM card so that you can ask your provider for activation of additional functions without the necessity to remove your SIM card from the device.



There are no more alarm SMS after a new SIM card has been inserted

1. First make sure that the change of the provider has been set in the modem and the modem is connected successfully to the GSM/3G/4G network (see chapter 12.7.2, resp. 12.7.3.3). If so, check the settings of
2. the alarm recipients in register "Alarm recipients". Make sure the correct phone numbers are entered and the
3. correct provider is displayed. Subsequently click on "Transfer SMS Alarm recipients".



Telemetry System and Related Systems of Ministry of Land, Infrastructure, Transport and Tourism (MLIT) in Japan

July 25, 2024
Nippon Koei Co., Ltd.
Kenya Water Resources Advisor
Y. AZUMA

Contents

1. General of Telemetry System
2. Related Systems
3. Advantages of Telemetry System
4. Standard Specifications by MLIT
5. No.54 Standard Specifications for Telemetry Equipment
6. Equipment of Gauging Station
7. Portal site of MLIT's River Information System
8. X-band Radar Rain Gauge
9. Project Achievement

Telemetry System and Related Systems of Ministry of Land, Infrastructure, Transport and Tourism (MLIT)

General of Telemetry System

- The telemetry system that obtains, records, and distributes hydrological observation data in real time from remote locations.
- Six types of data: rainfall, water level, dam quantities, snowfall, water quality, and coastline.
- More than 25,000 sets have been installed and operated in all over Japan.
- The telemetry system have exported to Philippines, Indonesia, Vietnam, Pakistan, Myanmar and Morocco through Japanese ODA projects (Grant Aid and Loan Projects)

General of Related Systems (1 of 4)

- **C-band radar rainfall gauge** has been operated in 1976 and capitulation with the telemetry rainfall data has started in 2003, which is aimed to improve accuracy of measurement data.
- **X-band radar Multi Parameter (MP) radar** information network called as XRAIN has operated in 2014.
- **XRAIN** can grasps the detailed rainfall situation in a small area and improves the prediction of localized heavy rainfall and flood forecasts.
- **CCTV (Closed Circuit Television)** has monitored situation of rivers, facilities such as the gates and roads situation with a camera connected to the optic fibers.

General of Related Systems (2 of 4)

- River Information System

- This system collects and processes measurement data such as rainfall, river water levels, water quality, and dam water storage volume in the river basin using telemeters to facilitate water management measures (flood management, dam management, flow monitoring, and water quality management).
- This data is used to forecast floods and control river management facilities, and is also distributed to local governments, etc., helping to improve the quality of river management by quickly and accurately determining river conditions during floods and droughts.



General of Related Systems (3 of 4)

- Dam and weir management system

- This system allows for safe, reliable and rapid management of dams and weirs
- Large-scale display system for disaster countermeasures
- The Disaster Countermeasures Room, which collects and responds to disaster information, is equipped with a large-scale display system that can centrally display CCTV camera footage and observation data.



General of Related Systems (4 of 4)

PLATEAU: PLATform for Advanced urban data and Urban planning

- This is a project led by the MLIT to develop, utilize and open-source **3D city models** across Japan. It is an open innovation initiative that was launched quickly in the wake of the COVID-19 pandemic, expanding the possibilities for public-private collaboration.
- This makes open data on 3D city models across Japan, thereby contributing to the creation of a sustainable society in which everyone can live and participate. 3D city models make urban spaces visible in three dimensions and provide a platform that enables a wide range of simulations and interactions.

Advantages of Telemetry System (1 of 2)

• Real-time monitoring:

Telemetry system can collect data from remote locations in real time, allowing you to instantly understand hydrological observations, weather information, and more.

• Efficient data collection:

Automated data collection processes allow data to be collected without human intervention. This results in efficient and accurate data.

• Early warning and forecasting:

Telemetry systems can detect abnormal values and fluctuations and send early warnings. This allows disasters such as floods and landslides to be predicted and countermeasures taken.

Advantages of Telemetry System (2 of 2)

• Remote control:

Telemetry systems can be controlled from remote locations, allowing facilities such as dams and floodgates to be operated remotely.

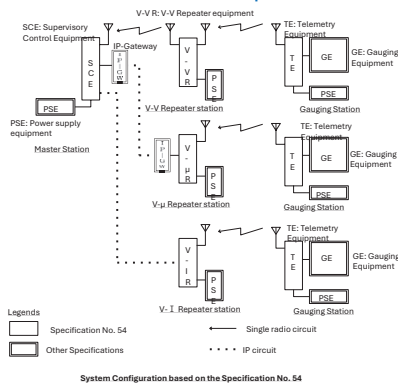
• Data recording and analysis:

Long-term data can be recorded and analyzed to understand hydrological trends and patterns.

Standard Specifications by MLIT

- No. 21 Standard Specifications for Telemetry Equipment (January 2001)
- No. 22 Standard Specifications for 70 MHz Radio Telemetry and Telecontrol Equipment (July 2011)
- No. 23 Standard Specifications for 70 MHz Radio Telemetry and Telecontrol Equipment (July 2011)
- No. 27 Standard Specifications for Flood Warning Equipment (September 2018)
- **No.54 Standard Specifications for Telemetry Equipment – Self Reporting (July 2011)**

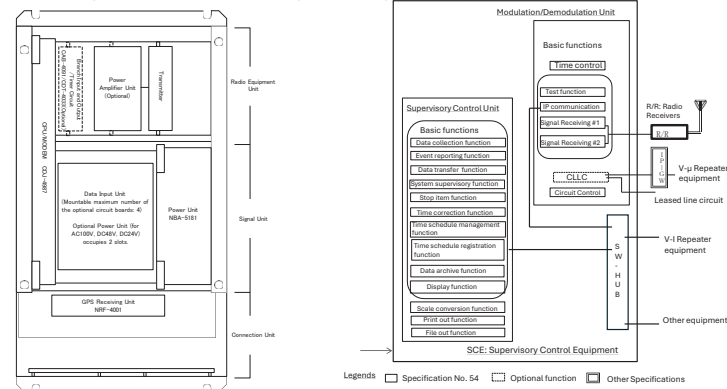
No.54 Standard Specifications for Telemetry Equipment



Main features:

- Telemetry equipment send measured data automatically by setting time through GPS.
- Time settings: 1 min., 5 min. 10 min., 30 min. and 1 hour,
- Event reporting: In case that data is measured, the telemetry equipment send the data automatically.

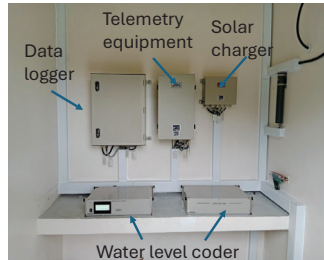
Components of Telemetry and Supervisory Control Equipment



Equipment of Gauging Station



Outline of rainfall and water level gauging station



Equipment of Gauging Station



Rainfall gauge
Solar panel

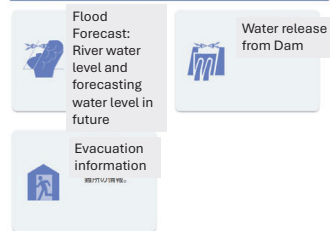


W/L sensor inside of maintenance box and protected with gabions

Portal site of MLIT's River Information System

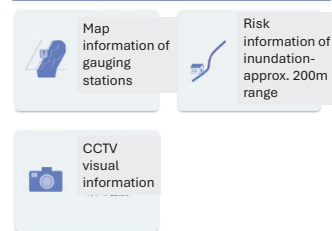
Announcement from the public government unit

行政からの発表を調べる



Check the river conditions

川の状況を調べる



Portal site of MLIT's River Information System

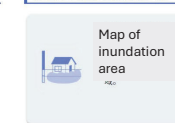
Checking rainfall status

雨の状況を調べる



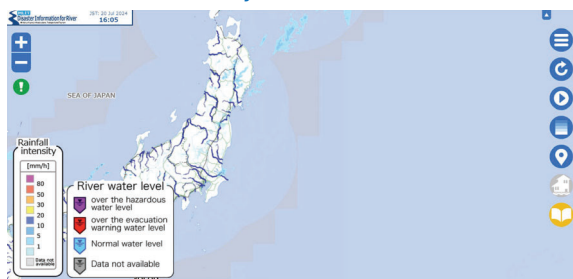
Checking inundation area

氾濫時の浸水範囲を調べる



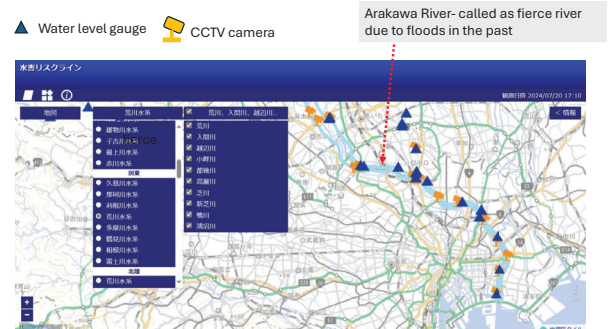
Portal site of MLIT's River Information System

Rainfall Intensity River water level

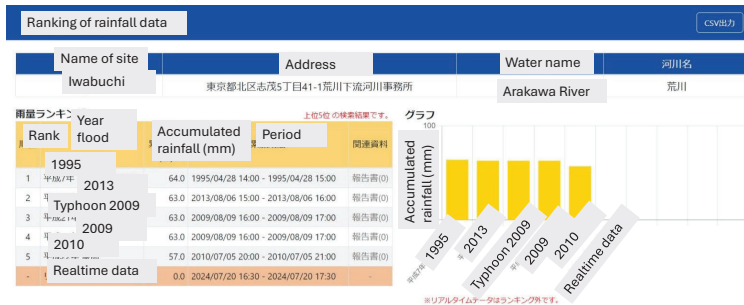


Portal site of MLIT's River Information System

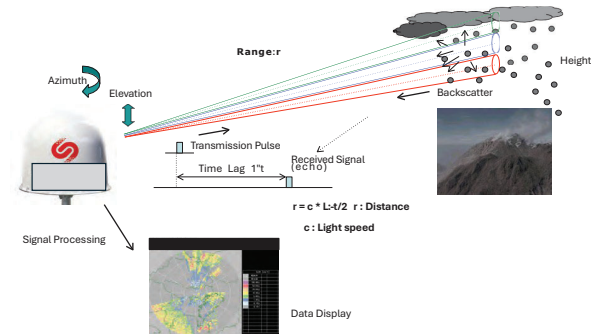
Map of Water level gauge and CCTV camera



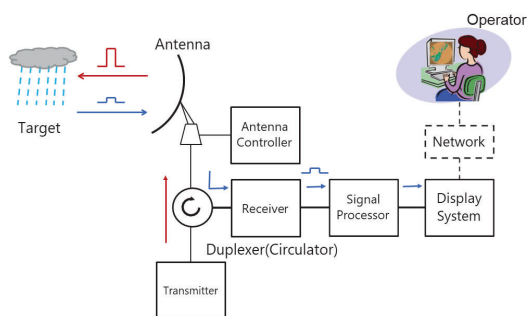
Portal site of MLIT's River Information System Ranking of Rainfall



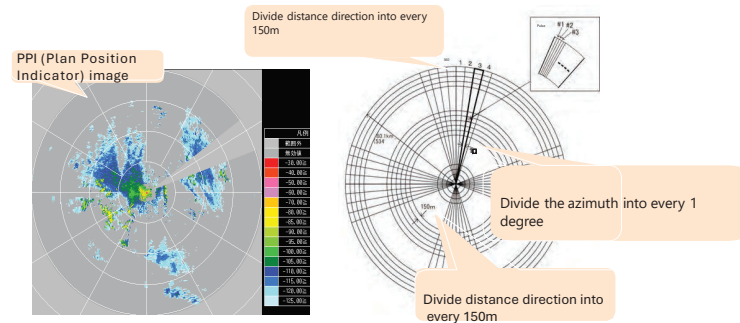
X-band Radar Rain Gauge What is radar? Weather RADAR System



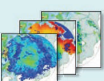
X-band Radar Rain Gauge What is radar? Basic Radar System Configuration



X-band Radar Rain Gauge What is radar? Processing data image



X-band Radar Rain Gauge Type of Radar

TYPE	RANGE	TARGET
S-band (2GHz)  S-band antenna and radar unit 400km Large	Wide area weather Typhoon, Hurricane, Cyclone  Tropical cyclone satellite image  Weather map showing typhoon/hurricane	
C-band (5GHz)  C-band antenna and radar unit 300km Middle	Meso-scale weather, Aeronautical weather conditions  Aeronautical weather radar image  Weather map showing meso-scale conditions	
X-band (9GHz)  X-band antenna and radar unit 120km (Typical 50km) Small	Weather Condition of Regional Area, Urban / provincial area, Local Airport  Weather radar image of regional area  Weather map showing regional area	
All-in-One	Mobile Type  Mobile weather radar unit	

X-band MP Radar Comparison of X-band and C-Band radars

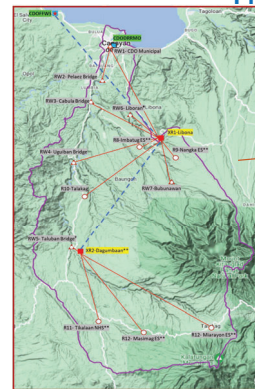
By introducing a high-frequency, high-resolution X-band MP radar in urban areas, we will strengthen on-site observations to reduce damage caused by localized heavy rain (so-called guerilla downpours) and torrential rains.

Compared to conventional radar (C-band radar), observations can be made at a higher frequency (5 times) and with a higher resolution (16 times). In addition, the time required for distribution has been reduced from 5 to 10 minutes to 1 to 2 minutes.

X-band MP Radar Comparison of X-band and C-Band radars

Radar type	C-Band Radar	X-Band Radar
Frequency/Wave-length	4 – 8 GHz, approx. 5 cm	8 -12 GHz, approx. 3 cm
Purpose of measurement	Live rainfall monitoring (long range)	Live rainfall monitoring (short range) Rain cloud movement observation
Measurement interval	5 min.	1 min,
Time lag	5 – 10 min.	1 – 2 min
Resolution	1 km	150/250 m

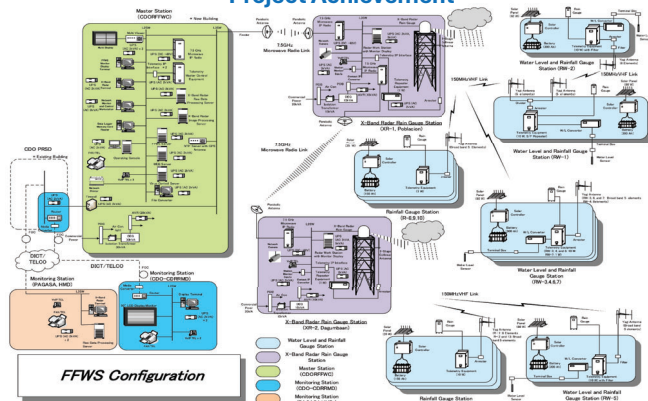
Project Achievement



History and General information on the Project;

- Typhoon in 2011 brought 1,250 dead and flood occurred in CDO city.
- Basin area: 1,364 km²
- Flood reach time from upstream to the CDO city: 7 hours

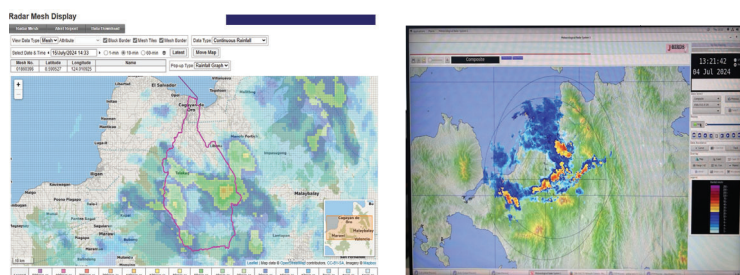
Project Achievement



Project Achievement X-Band radar site



Project Achievement X-Band radar output display



Thanks

**SUBJECT: WATER RESOURCES REAL-TIME TELEMETRIC EQUIPMENT,
DATA ACQUISITION AND MANAGEMENT CAPACITY BUILDING**

VENUE: EMBU REGIONAL OFFICE

DATE: 24TH JULY 2024

TIME: 11:00AM

NO	NAME	INSTITUTION	DESIGNATION	STATION
1	Jackline Mutinda	WRA	Technical Manager	Embu
2	Denis Masika	JICA Experts Team	Hydrologist	Nairobi
3	Yahya Aden	WRA	Hydrologist	Murang'a
4	Billon Gitonga	WRA	I.C.T	Meru
5	Gitari Shareen	WRA	Attachee	Embu
6	Roy Ngari	WRA	Attachee	Embu
7	Esekon Diana	WRA	Attachee	Embu
8	Brian Kisaka	WRA	Intern	Embu
9	Raphael Waruingi	WRA	Intern	Embu
10	Rueben Ngessa	WRA	Assistant Manager Hydrology	Headquarters
11	Jane Njuguna	WRA	Hydrologist	Kerugoya
12	Samuel Ndung'u	WRA	Hydrologist	Embu
13	Doreen Iluba	JICA Experts Team	Secretary	Nairobi
14	Joram Kihumba	WRA	Water Quality & Pollution Control	Embu
15	Eugen Mwandoe	JICA Experts Team	Communication Expert	Nairobi
16	Yasushi Azuma	JICA Experts Team	Telecommunication/ Innovation	Nairobi
17	Cynthia Wacuka	Regional Center for Ground Water	Hrdro- Meteorologist	Nairobi
18	Mercy Mbaya	WRA	Hydrologist	Meru
19	Gilbert Maiyo	JICA Experts Team	Water Resource Specialist	Nairobi
20	Josiah Maina	WRA	Knowledge Management Officer/I.C.T	Headquarters

**SUBJECT: WATER RESOURCES REAL-TIME TELEMETRIC EQUIPMENT,
DATA ACQUISITION AND MANAGEMENT CAPACITY BUILDING**

VENUE: EMBU REGIONAL OFFICE

DAT 25TH JULY 2024

TIM 9:00AM

NO	NAME	INSTITUTION	DESIGNATION	STATION
1	Josiah Maina	WRA	Knowledge Management Officer/I.C.T	Headquarters
2	Jane Njuguna	WRA	Hydrologist	Kerugoya
3	Rueben Ngessa	WRA	Assistant Manager- Hydrology	Headquarters
4	Cynthia Wacuka	Regional Center for Ground Water	Hrdro- Meteorologist	Nairobi
5	Mercy Mbaya	WRA	Hydrologist	Meru
6	Brian Kisaka	WRA	Intern	Embu
7	Esekon Diana	WRA	Attachee	Embu
8	Roy Ngari	WRA	Attachee	Embu
9	Gitari Shareen	WRA	Attachee	Embu
10	Billon Gitonga	WRA	I.C.T	Meru
11	Yahya Aden	WRA	Hydrologist	Murang'a
12	Denis Masika	JICA Experts Team	Hydrologist	Nairobi
13	Gilbert Maiyo	JICA Experts Team	Water Resource Specialist	Nairobi
14	Doreen Iluba	JICA Experts Team	Secretary	Nairobi
15	Eugen Mwandoe	JICA Experts Team	Communication Expert	Nairobi
16	Yasushi Azuma	JICA Experts Team	Telecommunication/ Innovation	Nairobi
17	Pauline Nyamu	WRA	Hydrologist	Embu
18	Joram Kihumba	WRA	Water Quality & Pollution Control	Embu
19	Samuel Ndung'u	WRA	Hydrologist	Embu

25th July 2024

**SUBJECT: WATER RESOURCES REAL-TIME TELEMETRIC EQUIPMENT,
DATA ACQUISITION AND MANAGEMENT CAPACITY BUILDING**

VENUE: EMBU REGIONAL OFFICE

DATE: 26TH JULY 2024

TIME: 9:00AM

NO	NAME	INSTITUTION	DESIGNATION	STATION
1	Rueben Ngessa	WRA	Assistant Manager-Hydrology	Headquarters
2	Doreen Iluba	JICA Experts Team	Secretary	Nairobi
3	Denis Masika	JICA Experts Team	Hydrologist	Nairobi
4	Yahya Aden	WRA	Hydrologist	Murang'a
5	Billon Gitonga	WRA	I.C.T	Meru
6	Gitari Shareen	WRA	Attachee	Embu
7	Mercy Mbaya	WRA	Hydrologist	Meru
8	Cynthia Wacuka	Regional Center for Ground Water	Hrdro- Meteorologist	Nairobi
9	Jane Njuguna	WRA	Hydrologist	Kerugoya
10	Samuel Ndung'u	WRA	Hydrologist	Embu
11	Josiah Maina	WRA	Knowledge Management Officer/I.C.T	Headquarters
12	Eugen Mwandoe	JICA Experts Team	Communication Expert	Nairobi
13	Raphael Waruingi	WRA	Intern	Embu
14	Wilson Githu	WRA	I.C.T	Embu
15	Gilbert Maiyo	JICA Experts Team	Water Resource Specialist	Nairobi
16	Christine Kinyua	WRA	Attachee	Embu
17	Esekon Diana	WRA	Attachee	Embu
18	Brian Kisaka	WRA	Intern	Embu

Appendix 12

Guidelines for Quality Control of Hydro- meteorological Data

Water Resources Authority

JAPAN INTERNATIONAL COOPERATION AGENCY/
KENYA WATER RESOURCES ADVISOR

Guideline for
Quality Control
of Hydro-meteorological Data

September 2024

NIPPON KOEI CO., LTD

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Abbreviations

RGS	Regular Gauging Stations
BO	Basin Office
SBO	Sub Basin Office
QC	Quality Check

1 Objective of Guideline

This guideline aims to support the quality assurance of Regular Gauging Stations (RGS) data and telemetric data in WRA.

When Sub Basin Office staff receive Gauge data from Gauge Readers, Quality Check (QC) is conducted before uploading data into the Sub-Basin Database. Officer in charge of Regional Office conduct data QCs before uploading into Regional Database. Database office at WRA headquarters carry out data quality checks and gives feedback to the ROs. However, there are no standards for QC. In addition, there are also no standards and/or guideline for QC of telemetric data managed by Headquarters (HQs).

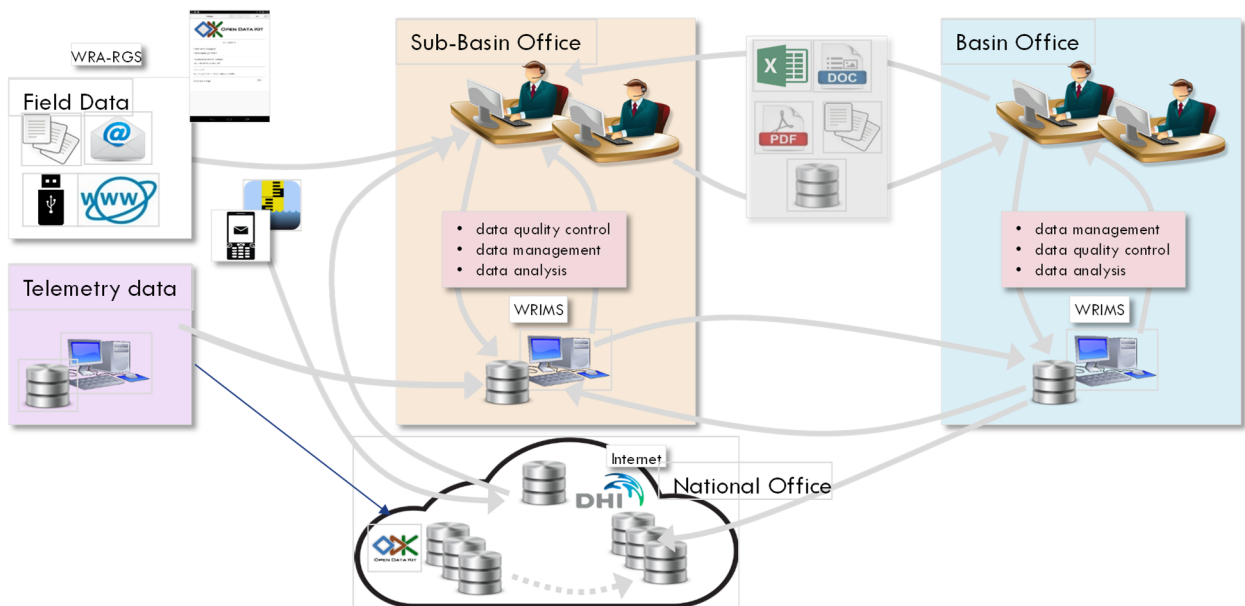


Figure 1-1 Procedure of Data Management including Quality Check

2 Items and Contents of Quality Checks

Figure 2-1 shows the sample data sheet of River Gauge Readings (RGS). Although the water level seems to be recorded twice a day, there are some unnatural points such as the water level being the same twice. Therefore, the JICA Expert Team proposes to check the check items shown in X when receiving the Data Sheet from the Gauge Reader.

 WATER RESOURCES MANAGEMENT AUTHORITY 00829
HYDROLOGY SECTION
WATER LEVELS RETURN

Rupingaz MTO
RIVER

MWEZI March MWAKA 2024
MONTH YEAR 19

KWA R.G.S HDCO3
FOR R.G.S BENSON
JINA LA MSOMAJI Muliha
NAME OF OBSERVER

Kwa Afisi Peki Yake
VIPIMO KWA FEET / METERS
READINGS IN

GHT 1	GHT 2	DATE SIKU	TIME 1 SAA 1	TIME 2 SAA 2	Kwa Afisi Peki Yake DISCHARGE 1 DISCHARGE 2 Q MEAN	REMARKS / CR MAELEZO
045	045	1	0700	0500		
045	045	2	0700	0500		
039	039	3	0700	0500		
036	036	4	0700	0500		
038	038	5	0700	0500		
036	036	6	0700	0500		
036	036	7	0700	0500		
035	035	8	0700	0500		
045	045	9	0700	0500		
043	043	10	0700	0500		
040	040	11	0700	0500		
038	038	12	0700	0500		
036	036	13	0700	0500		
036	036	14	0700	0500		
036	036	15	0700	0500		
035	035	16	0700	0500		
035	035	17	0700	0500		
035	035	18	0700	0500		
033	033	19	0700	0500		
035	035	20	0700	0500		
034	034	21	0700	0500		
034	034	22	0700	0500		
033	033	23	0700	0500		
033	033	24	0700	0500		
033	033	25	0700	0500		
034	034	26	0700	0500		
036	036	27	0700	0500		
037	037	28	0700	0500		
035	035	29	0700	0500		
039	039	30	0700	0500		
039	039	31	0700	0500	X	

Figure 2-1 Sample Data sheets of River Gauge Readings

Table 2-1 Items need to be checked

Gauge Readings	Time of Reading (0900hrs and 1600hrs)
	Units of readings recorded (m) or (cm), Recommended measurement units (m)
	Level of accuracy (to the nearest 0.01m)
Gauge range	whether data is within the installed gauge height -1m or 1.5m gauge
Precision/ Resolution (Number of digits)	Level of precision/ Resolution (0.00m)
Date	Date format (dd/mm/yy)
Data range	• Water level fluctuation exceeds upper limit Check data range using a time series plot against a historical data (99.7% Confidence Interval, 0.3% error margin)
Data trend	• Long-term continuation of the same water level • Unnatural water level records (water level is the same everyday on a daily basis)

3 Proposed quality check procedure for telemetry monitoring applicable in Kenya

The JICA expert team proposes the following procedure for the quality check of the telemetry station for water level. This procedure is based on the Japanese method. In Japan, once the data was digitized, quality check is often carried out automatically using Robotic Process Automation (RPA) tools.

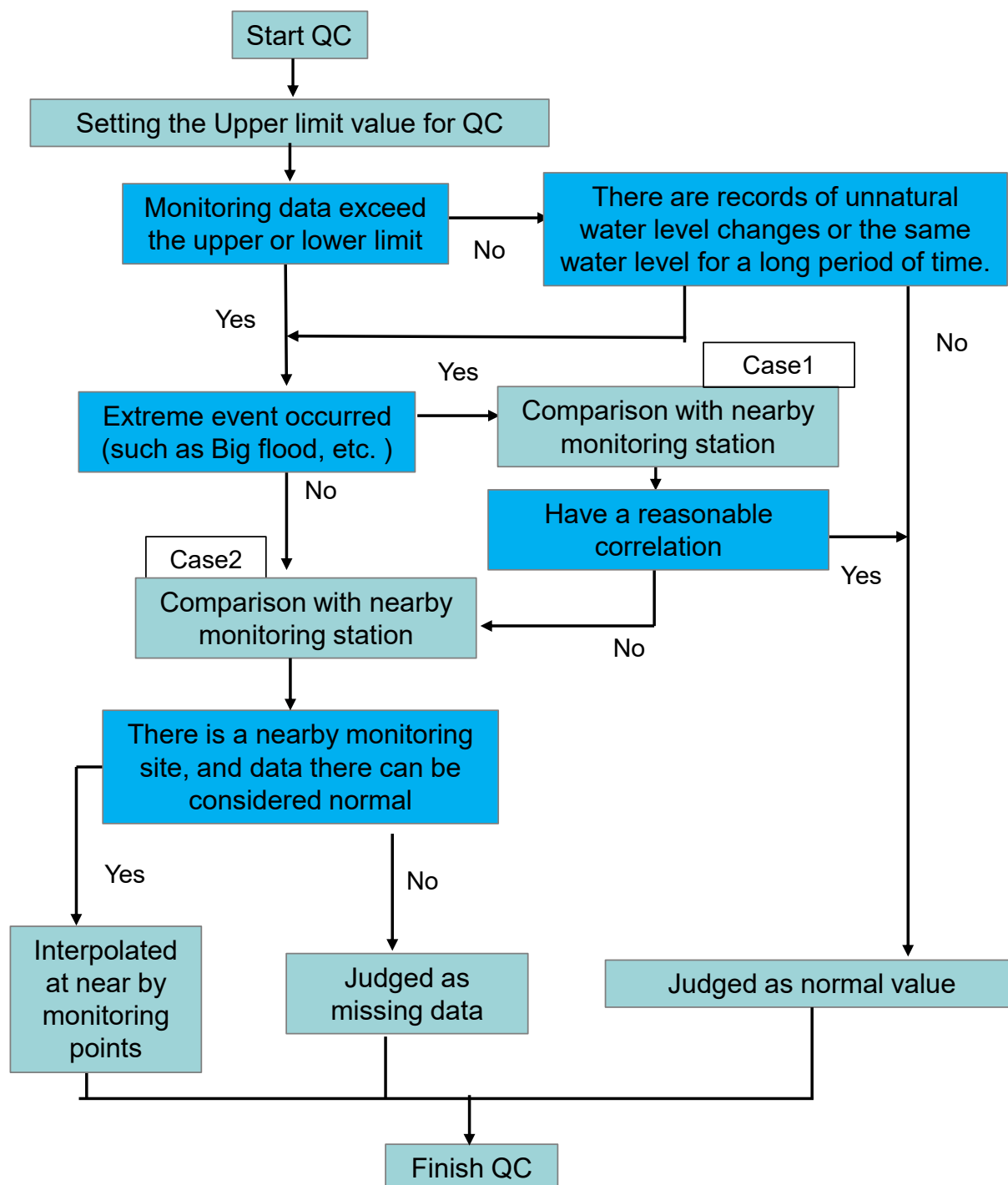


Figure 3-1 One of the examples of procedure of QC for telemetric stations data in Japan

3-1 Setting the upper/lower limit value for QC

Usually, upper and lower limit value of permanent monitoring data for QC is used $\mu + 3\sigma$ and $\mu - 3\sigma$.

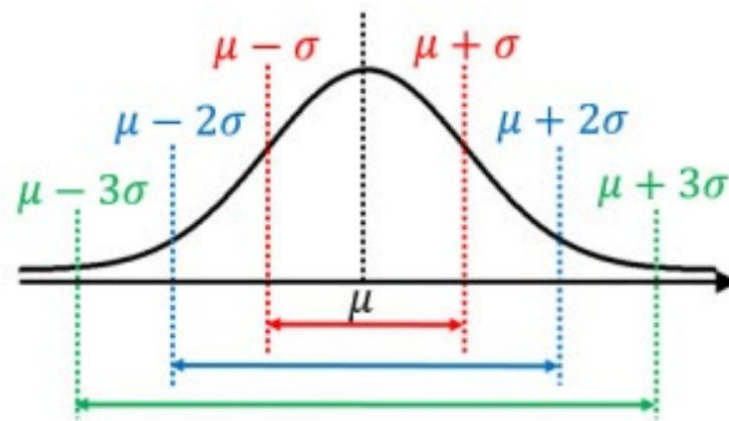


Figure 3-2 Upper and lower limit of permanent monitoring data for QC

Where

μ : Average, σ : standard deviation

3-2 Comparison with nearby monitoring station of case1

If there is a correlation between the time series data of the target monitoring station and a nearby monitoring station, it can be determined that the largest ever observed value was obtained. However, there is no correlation, there is a possibility that an abnormal value has been obtained.

The nearby observation stations need to be selected so that there are no confluences or divergences between them and the target station.

3-3 Comparison with nearby monitoring station of case2

For time-based water level data suspected of being abnormal, the validity will be examined based on the water level waveforms at upstream and downstream observation stations, dam discharge information, weir opening status, etc. and if it is found to be abnormal, it will be marked as missing.

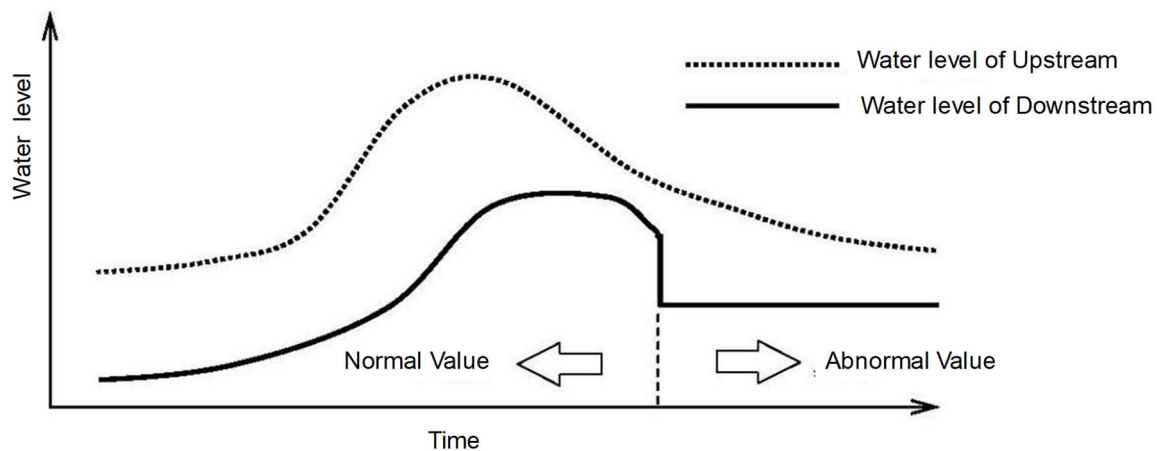


Figure 3-3 Example of Abnormal value

If there is a nearby monitoring station and data there can be considered, abnormal value can be replaced by interpolated value by nearby monitoring station data.

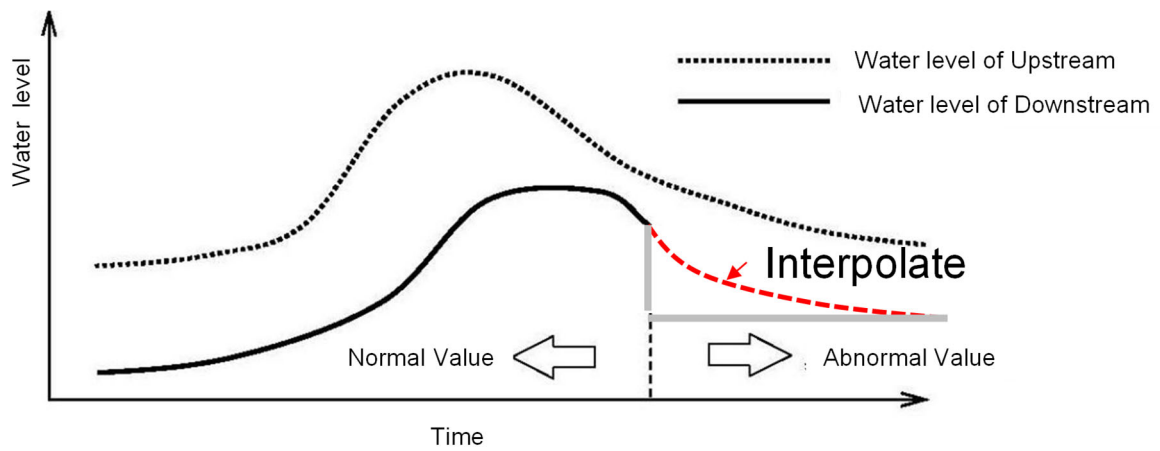


Figure 3-4 Example of interpolation by nearby monitoring station data

Appendix 13

**Meeting between WRA and JICA on
Progress and Status of Activities and
Issues (February 2, 2023)**

MEMO OF MEETING HELD IN WATER RESOURCE AUTHORITY (WRA) HEADQUARTER OFFICES

DATE: 2TH February 2023 VENUE: WRA HQ OFFICE-Nairobi TIME: 1400 hrs-1630hrs
Members Present

	WATER RESOURCES AUTHORITY	
	TITLE: Meeting Attendance Form	REF. NO.: F/18/1
	DEPARTMENT: Planning, Monitoring and Quality Assurance	ISSUE NO.: 06
	RECOMMENDED BY: Assistant Manager, Quality Assurance and Risk Management	REV. NO.: 05
	AUTHORIZED BY: CEO	DATE OF ISSUE: 26 th May 2021

Page 1 of 2

SUBJECT: JICA MEETING ON PROGRESS & STATUS OF ACTIVITIES AND ISSUES

VENUE: BOARD ROOM WRA 9TH FLR

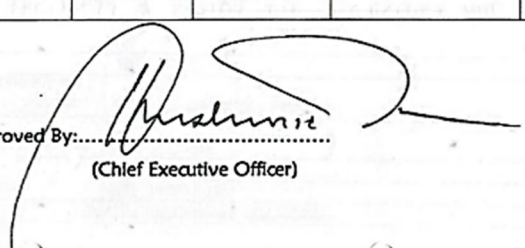
DATE: 2ND FEBRUARY 2023 TIME: 2:10 PM

S/No	Name	Designation/ Institution	Station	Phone	Email Address	Signature
1.	Mohamed M. Shure	WRA	HQ			
2.	John X. King'anyi	MWRA-PM	HQ			
3.	James Mburu	MCS/WRA	HQ			
4.	Jairo Otieno	WRA/WRA	HQ			
5.	KENNEDY OCHIENG	PH-WRA/WRA	HQ			
6.	Doreen A. Iuba	JICA Admin	WRA PIU Office			
7.	Denis Masika	Hydrogeologist JICA Expert	PIU Office			
8.	Eugen Mwandor Myamwili	Communication JICA Expert	PIU			
9.	ENG. GILBERT MAHO C.	Water Resource Engineer JICA Expert	PIU			

	WATER RESOURCES AUTHORITY	
	TITLE: Meeting Attendance Form	REF. NO.: F/18/1
	DEPARTMENT: Planning, Monitoring and Quality Assurance	ISSUE NO.: 06
	RECOMMENDED BY: Assistant Manager, Quality Assurance and Risk Management	REV. NO.: 05
	AUTHORIZED BY: CEO	DATE OF ISSUE: 26 th May 2021

Page 2 of 2

S/No	Name	Designation/ Institution	Station	Phone	Email Address	Signature
10.	Tadashi SHIMIZU	JICA Kenya	Nairobi			
11.	John Gitau	SPO JICA (K) Office	Nairobi			
12.	John N. Nguni	JICA Kenya	Nairobi			
13.	Takeshi Okamura	Nippon Koei Co. Ltd JICA Expert	Nairobi			
14.						
15.						
16.						
17.						

Approved By: 
(Chief Executive Officer)

MINUTE	DESCRIPTION	Action by
2023-02-02(a)	Introduction	
	The meeting commenced with brief introduction of members followed by presentation on progress on activities by JICA Expert Activities. The Team leader made presentation on progress of Activities and later presentation by National Experts on the current issues and way forward.	ALL
	The CEO requested for formal documentations for the project comprising the subsidiary agreement from the National treasury or MWSI. Such document he mentioned will assist in decision making and leverage on project activities to meet WRA mandate.	JICA
	The JICA representative explained that the current project was an ‘Individual Expert dispatch’ scheme which does not require a ‘record of discussion’ nor an MOU. Such scheme is based on a response to a request for service. He acknowledged the gap in communication and requested for further stakeholder engagements.	JICA
	It was decided that JICA and WRA will meet Director of Water Resources in MWSI for further coordination.	
	Technical Manager of WRA requested JICA for an advisory on increasing telemetering stations together with smart meters. The JICA representative asked the WRA team to make a write-up to clarify the request for consideration.	WRA
2023-02-02(b)	Progress of Activities	
	The summary of progress on the Activities by JICA expert work form the beginning of the assignment were elaborated through various JICA Expert visits:	
	In the previous JICA Expert Activities (2017 to 2019), four numbers of HIOKI Data loggers were supplied to WRA.	
	- Two numbers are still to be installed in Garissa and Muranga. - One station previously installed in Tana Rukanga RGS 4BE10 has since been vandalized. - The data logger at Kathita RGS 4F10 is operational.	Info
	On the other hand, three (3) stations were identified under present JICA Expert Activities for cross section survey and capacity building, stations 4F10 (Kathita, Meru), 4DC03 (Rupingazi, Embu) and 4AC03 (Sagana, Muranga).	JICA

MINUTE	DESCRIPTION	Action by
	The members were taken through the progress report and work plan with key issues pointed out for discussions. Apart from Task 1 desk activities, field surveys on identified stations were accomplished.	
	Additional cross section survey and updating of H-Q curves will be conducted 2 times within the year. [refer to detailed presentations].	Info
	WRA prefers HOBO type of data loggers which although not telemetric, it is simple to use, transfer data during monthly visits to site. Vandalism is not as common hence are secure.	JICA
	It was proposed that Automatic self-recording and data logger stations that do not transmit can be converted to real time self-recording, storage and transmitting i.e., telemetric station by simply installing an antenna and a receiving station thereby upgrading to telemetric stations.	WRA
	There is however a need to clarify the roles different stakeholders play especially with respect to the installation of telemetric stations as reported before publishing the same for public consumption.	

2023-02-02(d)	Reactions	
	WRA categorises its station according to National, MU, IMU, and Special stations. The later may be dropped once the objective of setting them is attained. However, WRA collects data from such stations to bridge its gaps. The current number of stations (87 No.) in the Tana basin was a result of many actors' interests in the basin. The National, Management Unit stations remain the same, but the Intra-Management and Special stations have increased due to stakeholders' interests. For instance, Nairobi Water Fund installed several stations in the Thika sub-basin to monitor water flowing to Nairobi City.	WRA
	The intention to capacity-build WRA staff was received positively. However, WRA requested to bring staff from other regions to benefit from the proposed training. The project staff was requested to customize the training materials to comply with the existing WRA systems for sustainability such as the MIKE INFO platform.	JICA
	Training Module by JICA - WRA Experts be synchronized with DHI Mike suite software operated by WRA which has requisite licences for software.	
	It was revealed that there are many telemetric stations operated by WRA as well as other partners in upper Tana basin.	
	Technical Manager requested JICA team to activate by transferring the HOBO logger at Garissa to Grand falls station at RGS 4F13 where a major dam is soon to be constructed. Historically, the station had a cable way	

MINUTE	DESCRIPTION	Action by
	station complete with in-built winches and chart, pulley and clockwork type water level recorder station which stalled due to vandalism.	
	The discussions held at the Regional Office could be enriched with input from the Headquarters since the regional office may not be privy to some information significant to the project implementation.	
	It was reinforced that the project was mainly utilizing the equipment available in the sub-regional offices for discharge measurement and cross-section survey.	
	The JICA Kenya Office asked WRA to prepare concept note complete with budgetary estimates for decision by JICA. The document to contain staff needs, propose equipment required, and other facilities necessary for such a system.	WRA
	WRA requested advisory support on handling data transmission since the organization was in the process of setting up digital platforms for data transmission and storage. This was in line with the government and WRA's policy on the digitization of its operations and services. This is in acknowledgment the request is beyond the current project scope.	
	The sub-regional staff have had a challenge accessing the telemetric data from the server at Headquarters. This was due to logistical issues. However, a provision has since been made for them to access the same from their stations. Lack of access as expressed by the staff may be due to other technological challenges. It was also noted that the RO, SRO have password for accessing telemetric data at the field.	WRA
2023-02-02(e) Issues and Way forward		
	JICA - WRA Adviser Project Implementation Project Documents be All clarified between MWSI, WRA-HQ, and JICA Kenya Office constitute a meeting on the same within two weeks involving DWR Mr. Mogusu and Japan Desk Coordinator in Maji House.	
	WRA to consider capacity building of staff other than those in Tana.	WRA
	Possible establishment of Desk officer for Telemetric System .	JICA
	JICA Expert Team to consider support in form of 'software' to set up a Flood Early Warning System in Tana Basin.	
	The JICA representative asked the WRA team to make a write-up to clarify the request for consideration for telemetering system	WRA
	There being no other business the meeting closed at 4:40pm (EAT)	

PHOTO DOCUMENTATION



Progress Meeting
with WRA Senior
Management and
JICA Team
At WRA HQ, NHIF
Building Upper Hill
on 2nd February
2023
from 1400-1630hrs.

3. Progress of Activities (5/20)



- The 2nd works in Kenya: October to December 2021
 - Capacity Assessment on discharge measurement together with confirmation on available equipment for discharge measurement.



at RGS 4DA13 Kiringa



at RGS 4DA5 Murubara



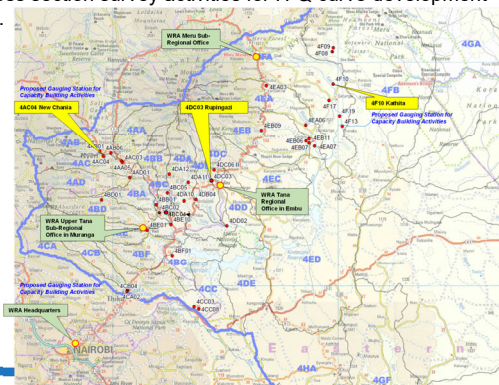
←4DC03 Rupingazi was additionally selected for discharge measurement and river cross section survey activities for H-Q curve development training.

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3. Progress of Activities (6/20)



- The 2nd works in Kenya: October to December 2021
 - All the selected three stations for discharge measurement and river cross section survey activities for H-Q curve development training.

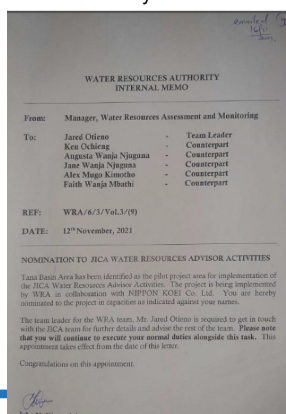


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3. Progress of Activities (7/20)



- The 2nd works in Kenya: October to December 2021
 - Counterpart Staff was finally nominated as of November 12, 2021 as follows:



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3. Progress of Activities (8/20)



- The 2nd works in Kenya: October to December 2021
 - Preparation of sublet works for discharge measurement and river cross section survey works:
 - By referring to the Work Plan, JICA Expert Team prepared specification and candidate list of contractors for discharge measurement and river cross section survey works.
 - However, Tana RO informed JICA Expert Team that such works are to be done by WRA themselves.

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3. Progress of Activities (9/20)



- The 3rd works in Kenya: February to April 2022
 - Change of candidate discharge measurement station:
 - From 4AC04 New Chania to 4AC03 Sagana due to damages to 4AC04 and no remedy works were expected.
 - Change of counterpart staff
 - Nominated counterpart staff Ms. Augusta Wanja Njuguna was assigned to Upper Tana Nairobi Water Fund Project. Successor was decided to be Mr. Samuel Ndungu (Surface Water Officer).
 - Discharge measurement and river cross section survey were conducted in the designated RGSs.

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3. Progress of Activities (10/20)



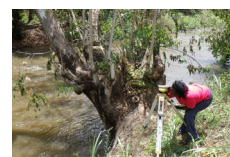
- The 3rd works in Kenya: February to April 2022
 - Discharge measurement and river cross section survey (first time)



Discharge measurement at RGS 4DC03 Rupingazi on March 18, 2022



←River cross section survey at RGS 4AC03 Sagana on March 29, 2022

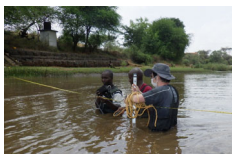


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3. Progress of Activities (11/20)

• The 3rd works in Kenya: February to April 2022

- Discharge measurement and river cross section survey (first time)



Discharge measurement at RGS 4F10 Kathita on March 31, 2022



Wrap up meeting at Meru SRO after discharge measurement at RGS 4F10 Kathita on March 31, 2022



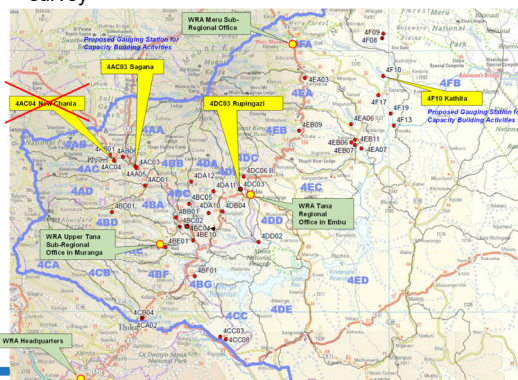
← Levelling equipment kept at Meru SRO which was used for river cross section survey at 4F10 Kathita on March 31, 2022.

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3. Progress of Activities (12/20)

• The 3rd works in Kenya: February to April 2022

- Final locations for discharge measurement and river cross section survey



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3. Progress of Activities (13/20)

• The 4th works in Kenya: May to June 2022

- Confirmation of current procedures for Hydrological Data Observation → Storage → Analysis with Tana RO TM.
 - SRO receives WL data from gauge readers →
 - SRO send WL data to RO →
 - RO check the WL data and convert them to discharge data →
 - RO send discharge data to HQ
- RO to prepare Flow Duration Curve (FDC) quarterly and report to HQ
- HQ publish Hydrological Year Book in the web page.

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3. Progress of Activities (14/20)

• The 4th works in Kenya: May to June 2022

- Confirmation on the status of WL monitoring stations.

Status of Regular Gauging Stations in Tana Basin Area

	Total	Operational	Not Operational	Telemetry Station	Data Logger	Vandalized	Need Rehabilitation
Kerugoya	13	13	0	7 (54%)	0	1	2 (15%)
Muranga	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%)

As a result, it was realized Tana Basin Area observes 87 stations against recommended 26 stations in NWMP 2030. Muranga has the largest number of stations as 53.

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3. Progress of Activities (15/20)

• The 4th works in Kenya: May to June 2022

- Confirmation on the status of Data Logger provided by previous JICA expert activities.
 - Four data loggers were provided by previous JICA Expert Activities (2017-2019)
 - The status is as follows:
 - One is installed at 4F10 Kathita in Meru SRO, functional
 - One was installed at 4BE10 Tana Rukanga in 2018, but it was vandalized in June 2021. The equipment was taken away. The station is left as it is (non-functional).
 - One is kept at Garissa SRO.
 - One is kept at Muranga SRO. Muranga SRO requested JICA Expert Team for assistance in installation of the data logger by construction of buildings. Total installation cost is estimated at KSh. 500,000 to 600,000.



← Hioki Data Logger with sensor cable, provided during the last JICA Expert Activities (2017-2019), and kept at Muranga SRO.

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3. Progress of Activities (16/20)

• The 4th works in Kenya: May to June 2022

- Status of other data loggers
 - Nairobi Water Supply (Nairobi Water Fund) installed US made HOBO data loggers.
 - Actually installed equipment was observed by JICA Expert Team at 4BE01 Maragua RGS. The cost of equipment was said to be KSh. 75,000.
 - HOBO Data Logger is of integrated type including sensor, memory, and battery. The data can be easily downloaded through USB cable to PC.



HOBO Data Logger with sensor cable at RGS 4BE01 Maragua



Retrieval of data into PC using USB cable

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3. Progress of Activities (17/20)

- The 5th works in Kenya: November to December 2022
 - Discharge measurement and river cross section survey (second time)



Discharge measurement at RGS 4DC03 Rupingazi on December 9, 2022 using propeller type current meter.

River cross section survey at RGS 4DC03 Rupingazi on December 9, 2022

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3. Progress of Activities (18/20)

- The 5th works in Kenya: November to December 2022
 - Discharge measurement and river cross section survey (second time)



←River cross section survey at RGS 4F10 Kathita on December 14, 2022

Due to high flow, Discharge measurement was not conducted.

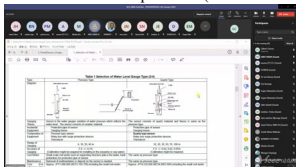


←River cross section survey and discharge measurement at RGS 4AC03 Sagana on December 19, 2022

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3. Progress of Activities (19/20)

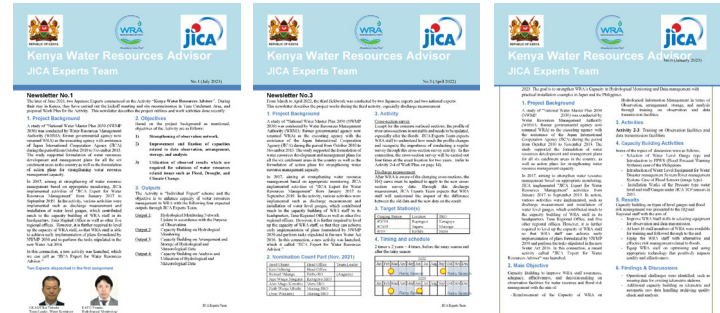
- Online seminar on January 12, 2023
- Mr. Y. Azuma Telemetering Expert conducted an online lecture as a part of: **Output 2 Capacity Building on Hydrological Monitoring**
 - Activity 2.3 Training of observation facilities and data transmission facilities.
 1. Date and Time: January 12, 2023 (Thursday) 10:00 to 12:00 a.m. (East African Time)
 2. Agenda:
 - (1) Selection of Water Level Gauge type and Introduction to FFWS case of Philippines
 - (2) Introduction of Water Level Equipment for Water Disaster management System/River management System- Case of Flood Sensors (image type)
 - (3) Installation Works of the Pressure type water level and staff Gauges under JICA TCP sensors in 2011.
 3. Number of Participants: 21 (16 from WRA and 5 from JICA Expert Team)



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3. Progress of Activities (20/20)

- Newsletter
 - As of the end of January 2023, JICA Expert Team issued six newsletters. The below listed show some of them.



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Water Resources Authority (WRA)

Kenya Water Resources Advisor

Status of Activities and Issues

February 2, 2023



1. Background Information (1/2)

- “Kenya Vision 2030” stipulates that [water is basic resource](#) to support development activities.
- To realize the Vision, an [appropriate planning and implementation structure](#) is prerequisite for the [water resources development and management](#).
- The Project on the Development of The National Water Master Plan 2030 in the Republic of Kenya (NWMP 2030) formulated Water Resources Development and Management Plans for the six catchment areas.
- NWMP 2030 supported preparation of [action plans for the strengthening of water resources management capacity](#).
- “Activities on Water Resources Advisor” was implemented from January 2017 to September 2019 aiming at strengthening of water resources management by selecting Tana Catchment Area as a pilot.

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1. Background Information (2/2)



- During the activities, various activities were implemented which include discharge measurement, installation of water level gauge etc.
- Those activities contributed a lot to capacity building of both WRA headquarters and Tana Regional Office.
- To perform tasks of WRA which are stipulated in Water Act 2016, it is required to further develop technical capacities of WRA staff based on activities implemented so far.

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2. Purpose of Activities



- The purpose of activities is to [improve skills of WRA staff](#) aiming at realizing strengthening of water resources management capacity in accordance with required [functions of WRA](#) which are stipulated in [Water Act 2016](#). Those skills improvement includes:
 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](#).

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3. Upper goal of activities



[Strengthening](#) of Water Resources Management [Capacity](#) by [WRA](#)

4. Goal of activities

[Strengthening of WRA's Capacity](#) on Hydrological Data Management (Observation, Arrangement, Storage, Analysis, and Utilization)

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5. Expected Outputs



- **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](#)

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6. Status of Activities and Issues (1/15)



- Output 1 **Hydrological Monitoring Network Update**
 - Activity 1-1:** Survey on recent flood and drought damages as well as countermeasures for such damages.

Current Issue	Way forward/Solution
Flood management is one of the tasks of WRA, but there are no activities for WRA staff during the flood. There are drought issues. However, sub-regional office staff only confirm and report the situation without any technical actions. For the preparation of drought, dissemination activities are being done to prevent the expansion of the damages, but there seems to be no activities such as rationing during drought. In principle, as naturalized flow is not properly evaluated, it is not clear how much abstractions are made at certain points. As for naturalized flow, the data of 1992 M/P is still used, and there seems to be no particular issues using such data. Therefore, there seems to be no critical sense on such issues.	- WRA clarified activities such as rationing by the sub-regions during drought. - Team to work with RO and SRO to select 2 - 3 pilot sub-basins that have water use conflicts or any other challenges. Maragua (4BE01) and Ragati (4BB01) were taken up as pilot. - Together, produce maps populated with legal water permit points of abstraction, naturalized discharge data and other related data to conduct water balances; - Develop updatable maps on the same for decision-making on new allocations, and conflict resolution by SROs - Continue collection of related data on floods and droughts.

- JICA expert team to further collect information, confirm with RO, SROs.
- Activities will continue up to **August 2023**.

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6. Status of Activities and Issues (2/15)



- Output 1 **Hydrological Monitoring Network Update**
 - Activity 1-2:** Survey on support activities by other development partners.

Current Issue	Way forward/Solution
Nothing in particular	- Nairobi Water Fund [NWF] is a major stakeholder in upper Tana and are presently active and have offices in Sagana. - The Funds are used to monitor hydrological and sediment monitoring in Tana River. The limit of work seems to end at the Masinga dam. - NWF currently maintains 28 Automatic stations with Hobo data logger with sensors. - KMD with support the World Bank installed 17 Telemetric stations. - Continually collect information and compile.

- JICA expert team to further collect information, confirm with HQ, RO, SROs.
- Activities will continue up to **November 2023**.

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6. Status of Activities and Issues (3/15)



- Output 1 **Hydrological Monitoring Network Update**
 - Activity 1-3:** Clarification on the positions/purposes of each observation station from the viewpoint of flood and drought risk evaluation.

Current Issue	Way forward/Solution
Report from WRA is different from actual operation. As indicated in (1-1) above, 1992 M/P data is still used as base for water right permitting, and so far, there is no particular issues using that base data. There seems to be no urgent needs for reviewing the monitoring networks. It looks that lack of staff is affected to some extent.	- WRA has 87 stations, 75 are presently in operation/data collected. - Flood and Drought Stations Identified: 4BE10, 4G01, 4G02, 4G04, 4F13, and 4DD02.

- JICA expert team to further collect information, confirm with RO, SROs.
- RO, SROs to provide information, and confirm.
- Activities will continue up to **April 2023**.

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6. Status of Activities and Issues (4/15)



- Output 1 **Hydrological Monitoring Network Update**
 - Activity 1-4:** Review of monitoring plan of Tana Catchment Area from the viewpoint of effective utilization of the observation results.

Current Issue	Way forward/Solution
Damaged monitoring stations are left as it is, and there seems to be no issues. Therefore, no budget is allocated. For the stations with poor security, stations are often vandalized, and it is difficult to secure budget for reinstallation. Intensive monitoring works are being made for those stations which are monitoring water distributed to Nairobi.	- WRA to clarify the purpose and need to maintain 87 stations against M/P recommendation of 26 stations. - WRA Regional office to prepare a report to justify why the recommendation should be appropriately altered from 26 to 87 stations. - To identify/develop a criterion to validate the hydrological telemetering. - WRA Regional Office to take the lead in coming up with a criterion for surface water RGS optimization. - Study the current spatial distribution of RGS's and rank them according to importance relative to neighboring station, position in the sub-basins, number of legal permits, frequency of request for abstraction applications etc. - For the stations often vandalized, it should be considered to shift the stations to safer locations.

- RO to prepare a report, provide information.
- JICA expert team to check and evaluate the report.
- Activities will continue up to **April 2023**.

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6. Status of Activities and Issues (5/15)



- Output 2 **Capacity Building on Hydrological Monitoring**
 - Activity 2-1:** Confirmation on operational status and analysis of issues on Observation Facilities and Data Transmission Facilities

Current Issue	Way forward/Solution
As a result of surveying 14 data transmitting systems in the upper Tana, there were 9 stations with more than 10% of lack of data. There are issues on the data capturing ratio as the maximum value of the lack of data was 81%. It seems that WRA staff do not rely on data transmitting system and just observe data manually or by using data loggers.	- JICA expert team continue identification of reasons for lack of data (mis-transmission). - Maintenance issues come up, especially if telemetric data is not shared with sub-regions to promptly identify. - Data Storage and utilization to be examined and assessed for each office (RO&SRO) for capacity building. - Issue of base station and server to be discussed further with HQ. - The JICA expert team to work with the SWO and ICT officers to update the H-Q curves for each station based on observation results at 4AC03 Sagana, 4DC03 Rupingazi, and 4F10 Kathita. - WRA Regional Office to take the lead in coming up with a criterion for surface water RGS optimization

- WRA HQ, RO, SROs to provide information.
- JICA expert team to check and analyze information.
- Activities will continue up to **April 2023**.

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6. Status of Activities and Issues (6/15)



- Output 2 **Capacity Building on Hydrological Monitoring**
 - Activity 2-2:** Support on Preparation of Plan of Operation for Data Transmission Facilities

Current Issue	Way forward/Solution
It is still not clear why WRA introduce data transmitting equipment. There is no clear guidelines of introduction.	The purpose and the policy of introduction of data transmitting equipment will be discussed with WRA. Required items for preparation of operation plan will be clarified and support the preparation of the plan. - WRA to provide criteria/steps towards for telemeterisation of stations. - Further capacity building on Installation and O&M was identified after discussions with regional offices. - Study the current spatial distribution of RGS's and rank them according to importance relative to neighboring station, position in the sub-basins, number of legal permits, frequency of request for abstraction applications etc.

- JICA expert team to assist preparation of operation plan.
- WRA to nominate candidate trainees for this activity.
- Activities will continue up to **August 2023**.

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6. Status of Activities and Issues (7/15)



• Output 2 Capacity Building on Hydrological Monitoring

- Activity 2-3: Training of Observation Facilities and Data Transmission Facilities

Current Issue	Way forward/Solution
It is not clear who to train and with which specialty the target trainee should have.	- Targeted staff for training identified as Surface Water Officer, ICT Officer, Community Development Officer, and Licensing Officer. - Prepare a list of staff from each sub-region for training. - Training needs to be identified.

- JICA expert team to prepare training material and conduct training.
- WRA to nominate candidate trainees for this activity.
- This training will be scheduled in **May 2023**.

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6. Status of Activities and Issues (8/15)



• Output 2 Capacity Building on Hydrological Monitoring

- Activity 2-4: Reinforcement of Capacity on Observation at site including preparation of H-Q Curve

Current Issue	Way forward/Solution
There is not sufficient observation equipment. Only Muranga SRO has sufficient equipment, therefore, other SRO borrows equipment from Muranga SRO. Lack of staff for observation.	- Procurement of minimum required equipment is necessary for sustainable observation operations. - WRA prefers carrying out observation work themselves instead of subletting. - The JICA expert team to work with the SWO and ICT officers to update the H-Q curves for each target station for training. - Prepare equipment List with specifications at each sub region-functional or non-functional. - Simple analysis is done in RO for quarterly water status report. JICA expert team will check when the HQ curves last updated.

- JICA expert team to conduct **joint measurement of river discharge and river cross section survey at: 4DC03 Rupingazi, 4CA03 Sagana, and 4F10 Kathita.**
- WRA to nominate candidate trainees for this activity.
- JICA expert to provide training for preparation of H- Q Curve.
- This training will be continued up to **November 2023**.

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6. Status of Activities and Issues (9/15)



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

- Activity 3-1: Quality Improvement Guidance and Preparation of Quality Control Standard

Current Issue	Way forward/Solution
<Meteorological Data> WRA only observes meteorological data inside SROs. <Hydrological Data> Gauge reading works are done by gauge readers, but there is issued on delayed payment of salaries (maximum one year delay). In addition, without available vehicles, it is difficult to conduct data collection works. Even under such situation, data collection is timely done.	Ask WRA for improvement of data collection issues as a very basic issue. It is scheduled to introduce practices in Japan for data check for consistency so that WRA staff can implement such check works. - Review the need for some manual gauges through the optimization exercise identified in previous section 2.1. - WRA reported that delayed payment of up to 1 year is acceptable and appreciated by the gauge reader. Only when there is prolonged non-payment, then it becomes an issue. - JICA expert team to organize lectures for quality improvement guidance.

- JICA expert to provide training for Quality Improvement Guidance.
- WRA to nominate candidate trainees for this activity. Also, advise any information on WRA's related activities on Quality Improvement.

- This training will be done in **May to June 2023**.

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6. Status of Activities and Issues (10/15)



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

- Activity 3-2: Confirmation on the Current Status and Improvement on Operation and Management of Database

Current Issue	Way forward/Solution
Database is installed in offices; however, SRO only keeps the data and RO only receive the data. There is no systematic utilization and management of data. Even in case the data is not acquired, there is no issue.	By fully using the manual for the existing database, identify the works that are not implemented and implement training. - JICA expert team discussed the role of RO and SRO on data utilization and management since they are involved directly with issuing permits by giving recommendations to HQ. - Capacity building on data management was identified. - JICA expert team to organize sessions to identify issues on operation and management of database, then facilitate lectures as necessary.

- JICA expert to organize sessions to identify issues on operation and management of database, then facilitate lectures as necessary.
- WRA to provide information on issues on database, nominate candidate trainees for this activity.

- This training will be done in **May to June 2023**.

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6. Status of Activities and Issues (11/15)



• 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

Current Issue	Way forward/Solution
It is designated for JICA Expert to make guidance on arrangement of discharge data, probability analysis, and climate change effect, however, in principle, WRA does not have sufficient base for preparation of such analytical works.	JICA Expert Team will show how to arrange and analyze the data, prepare manuals and guidelines. - WRA to furnish requisite data to the JICA team for developing training modules, especially on raw data probabilistic analysis. - JICA expert team will provide the necessary capacity building on data analysis. - JICA expert team requested WRA to inform the type of analysis which WRA needs to acquire.

- JICA expert to arrange trainings on Flow Regime Arrangement/Compilation and Probabilistic Analysis.
- WRA to provide basic data to be used for training, nominate candidate trainees for this activity.
- This training will be done in **March to May 2023**.

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6. Status of Activities and Issues (12/15)



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

- Activity 4-2: Analysis Climate Change Affect

Current Issue	Way forward/Solution
Observed data is not properly arranged.	Guidance will be made on analytical method of climate change possibly by utilizing the actual observation data. - Climate impact module shall be included in the capacity building to form models generated with possible climate [especially Temperature & precipitation] scenarios explored. - JICA expert team to consult with RO and SRO for target topics for climate change analysis.

- JICA expert to arrange trainings on Climate Change Affect Analysis.
- WRA to provide basic data to be used for training, nominate candidate trainees for this activity.
- This training will be done in **May to June 2023**.

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6. Status of Activities and Issues (13/15)



- Output 4 Capacity Building on Analysis and Utilization of Hydrological and Meteorological Data
 - Activity 4-3: Discussion and Compilation on the Function of WRA as well as Utilization of Monitoring Results aiming at Flood Damage Mitigation

Current Issue	Way forward/Solution
So far there seems to be no activities of WRA during flood.	Discuss with related sections of WRA to grasp the actual situation, then rectify WRA's function. - Through discussion with RO and SROs, it was identified that WRA is using stations 4G01 Garissa, 4G02 Garsen, 4G04 Hola, 4F13 Grand Falls, and 4DD02 Thiba for flood monitoring and warning. - Riparian marking is being done with communities through pegging to show highest flood. Those pegging will help people having damages by restrictions of building houses, cultivating lands, damp waste, quarry stones, and sand harvesting. - JICA expert team to identify more to describe actual situation.

- JICA expert organize discussion with RO and SROs to obtain information, compile, the publish such activities in the newsletter.
- WRA to provide basic information on activities.
- This activity will be done from **February to June 2023.**

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6. Status of Activities and Issues (14/15)



- Output 4 Capacity Building on Analysis and Utilization of Hydrological and Meteorological Data
 - Activity 4-4: Discussion and Compilation on the Measures during Droughts as well as Utilization and Analysis of Monitoring Results

Current Issue	Way forward/Solution
So far there seems to be no activities of WRA during drought.	Discuss with related sections of WRA to grasp the actual situation, then rectify WRA's function. - Through discussions with RO and SROs, it was identified that some RGSs use drought warning water level. For example, at 4G01 Garissa, in case the water level becomes lower than 2.5 m, irrigation water abstraction upstream is restricted. At the time of drought, daytime irrigation water use is suspended generally. Irrigation water can only be used during nighttime. - JICA expert team to identify more to describe actual situation.

- JICA expert organize discussion with RO and SROs to obtain information, compile, the publish such activities in the newsletter.
- WRA to provide basic information on activities.
- This activity will be done from **February to June 2023.**

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6. Status of Activities and Issues (15/15)



- Output 4 Capacity Building on Analysis and Utilization of Hydrological and Meteorological Data
 - Activity 4-5: Publication and Notification to Related Organizations on the Hydrological and Meteorological Data

Current Issue	Way forward/Solution
So far water permit issuance is using water allocation guidelines based on 1992 M/P data.	Discuss with related sections of WRA who conduct analytical works to confirm whether any data can be published or not. - Assessment of Information sharing, and organization of hydro met data. - Through the capacity building tasks identified, update water allocation plans and guidelines and make further recommendations. - JICA expert team to consult with WRA HQ and RO for assistance on publication of information such as preparation of Hydrological Year Book or Water Resources Situation Report.

- JICA expert to consult with WRA HQ and RO on which data to publish.
- WRA HQ and RO to participate in the discussions on publishment.
- This activity will be done from **October to November 2023.**

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7. Assignment Schedule



Assignment Schedule																																															
Name (in charge)	2021												2022												2023												2024										
	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3													
Mr. T. Okamura (TL/WRM)																																															
Mr. Y. Kato (HM/FDRA)																																															
Mr. Y. Azuma (Telecom/Innov. Tech.)																																															

Note:
TL/WRM: Team Leader/ Water Resources Management, HM/FDRA: Hydrological Monitoring/ Flood and Drought Risk Assessment
Telecom/Innov. Tech.: Telecommunication/ Innovation Technology

Feb. 2, 2023

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8. Work Locations



- Major Activities at WRA headquarters
- Practical Site Activities at Tana Basin Area
- As of January 2023, it is reported that the safety condition is not preferable in Garissa and further downstream areas.

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End of Presentation



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Appendix 14

**An Official Letter from MWSI to WRA on the
Acceptance of the JICA Experts for WRA
(April 17, 2023)**



REPUBLIC OF KENYA
MINISTRY OF WATER, SANITATION AND IRRIGATION
STATE DEPARTMENT OF WATER AND SANITATION
OFFICE OF THE PRINCIPAL SECRETARY

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REF: MWSI/OFTA/12/12TY/49

17th April, 2023

Mr. Mohamed M. Shurie
Chief Executive Officer
Water Resources Authority
NAIROBI

Dear

**RE: ACCEPTANCE OF JICA EXPERTS FOR WATER RESOURCES
AUTHORITY**

This refers to Japan International Corporation Agency (JICA) letter Ref. No. GA-21-021(M) dated 28th May 2021, on the above subject. As you are aware JICA has been supporting this Ministry in many area including a project titled "Water Resources Management Expert" which was implemented in conjunction with Water Resource Authority (WRA) agency which aimed at providing the agency with short term technical expert.

We wish to advice that the Ministry of Water, Sanitation and Irrigation has accepted the Official Development Assistance (ODA) of the Government of Japan through the Japan International Cooperation Agency (JICA) to support Water Resources Management under "Individual Expert Scheme".

The project aims at enhancing water resource management of Water Resources Authority in accordance with the functional requirement by Water Act 2016, by developing the human capacity in the following aspects.

1. Strengthening of the monitoring network,
2. Improvement and fixation of capacity on data observation, arrangement, storage and accumulation and analysis, and
3. Utilization of observation results towards solutions of actual water resources issues such as floods. Droughts, and climate change

Specific activities under each aspect should be discussed by WRA and the Experts dispatched under the Scheme.

So far, the Ministry has accepted three Experts:

1. Mr. OKAMURA Takeshi, Team Leader
2. Mr. KATO Yusuke, Hydrological Monitoring / Flood and Drought Risk Assessment
3. Mr. AZUMA Yasushi , Telecommunication / Innovation Technology

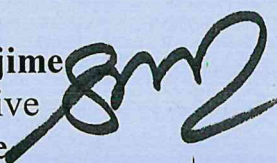
In view of the above, WRA is expected to assign relevant staff to support the activities under the Scheme and provide a workstation for the Japanese Experts.

Yours

Dr. Kipronoh Ronoh P.
PRINCIPAL SECRETARY

Copy to: **Hon. Alice Wahome**
Cabinet Secretary
Ministry of Water, Sanitation and Irrigation
NAIROBI

Mr. IWAMA Hajime
Chief Representative
JICA Kenya office
NAIROBI

 20.4.23

Appendix 15

A Sample Field Note for River Cross Section Survey and Discharge Measurement

Observation from (Left / Right) Riverbank*

Date (dd/mm/yyyy)		Time	begin		end	
gauge height	beginning	m		end		m
River Width			Measurer			
Measurement Location			Recorder			
Equipment used						
Remarks						

[illegible]

Appendix 16

Operation and Maintenance Manual for FFWS Equipment (Draft)

Kenya Water Resources Advisor

**OPERATION AND MAINTENANCE
MANUAL
FOR FFWS EQUIPMENT
(DRAFT)**

September 2024

Nippon Koei Co., Ltd.

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CHAPTER 1 GENERAL NOTES

1.1 Trend

Technology has been changed from “Analogue” to “Digital” and the equipment for the Flood Forecasting and Warning (FFWS) and Flood Early Warning System (FEWS) have also changed day by day.

The analogue telecommunication technology has been also changed to digital technologies, which are based on the Internet Protocol (IP) and networking technology consisting of the switch devices (called as Router, L2/L3 switch) and software applications for the networking/controlling. Due to the advanced digital technologies, radio equipment becomes compact design and cheaper price than analogue one, and most equipment are connected with the switches/routers controlling by the software called as IP network. The IP networking has been developed as open technology and widely used all over the world, so everybody can use it with cheaper cost.

In addition to the above, sensors are also innovated with the Internet of Things (IoT) technology.

Artificial Intelligence (A/I) will contribute to develop flood forecasting technologies.

Meanwhile, there are disadvantages as mentioned below:

- 1) Security measure shall be important and is essential in the IP network against hacking or cracking
- 2) Software knowledge is required to maintain the networking, particularly modification of networking configuration (changing IP setting value)
- 3) Digital equipment generally become like “black box” and all information related to the equipment design are not disclosed to the End User due to company secret avoiding imitation by third party, which is not easy maintenance by end users.

1.2 Aspects from O & M work

Manufacturers/Vendors could submit following information at past time (analogue equipment), so the end user could maintain the equipment to repair and to replace the parts through the electronic knowledge/skill:

- 1) Circuit diagrams

- 2) Parts list with the detailed information for replacement
- 3) Full explanatory manuals

However, as stated in the previous section, situation of the manufacturers/vendors and the required knowledge/skill have been changed as follow:

- 4) From the electronic to networking and software knowledge/skill
- 5) From “repairing” to “replacement” with spare parts which shall be planned timely considering budget

CHAPTER 2 GENERAL REQUIREMENTS FOR O & M WORKS

2.1 Definition of Maintenance Works

Maintenance works is defined as follows:

- 1) To check, repair, and adjust system equipment and facilities,
- 2) To keep clean and maintain system equipment and facilities in satisfactory condition,
- 3) To anticipate and prevent breakdown of system equipment, and
- 4) To restore system equipment to good operating condition.

2.2 Classification of Maintenance Works

Maintenance works are classified into five (5) main tasks below.

- 1) Inspection
- 2) Engineering
- 3) Cleaning
- 4) Clerical Work
- 5) Service output

2.2.1 Inspection

This is a routine task schedule which includes the checking of system and equipment condition, station house/building and its facilities. A report is made, and the corresponding repair or adjustment is suggested or required.

2.2.2 Engineering

Engineering work in maintenance is concerned with locating and identifying troubles, and determining the causes of failures and difficulties, and devising means for preventing their future occurrence.

2.2.3 Cleaning

This part of maintenance work is the most common and important because it is a routine/periodic activity. It is by far the easiest because it includes such work as cleaning equipment room/floors, equipment, station house/building; opening clogged water intake and other work that will contribute to the upkeep and improvement of the entire maintenance works. The following is a suggested routine office, equipment room, control room, and power room evaluation:

- 1) Are the office tables clean?
- 2) Are the work benches clean?
- 3) Is the test instrument arranged and ready for use?
- 4) Is the equipment clean?
- 5) Are the equipment and power rooms clean and the test instruments properly located in the shelves/cabinet or floor?
- 6) Are there cluttered parts and materials in the equipment room?
- 7) Are the wall and ceilings clean and free from cobwebs?
- 8) Is the floor free from dirt and dust?

2.2.4 Clerical Work

This type of maintenance work includes recording the history and condition of system equipment and facilities, keeping records of completion date of installation, repairs, modification and replacement of parts. These records are kept facilitating the maintenance work of such system equipment. Other records that should be kept include equipment layout, technical data, and specifications of system equipment.

2.2.5 Output Service

This maintenance work refers to the service output. This is where the suggested or required work as per inspections, is done. Such work may involve repairing a broken-down system equipment.

2.3 Categories of Maintenance Work

There are two general categories of maintenance work

1) Preventive Maintenance

This is concerned with the work to prevent the occurrence of trouble or breakdown of the system equipment.

2) Corrective (Breakdown) Maintenance

This refers to the work done to correct a trouble or defect after it had occurred. There are two terminologies to relate this maintenance work.

a) Maximum Maintenance

This means optimum repair to prevent system breakdown. This is done when it is cheaper to repair than to replace the unit, lack and equipment.

b) Minimum Maintenance

This means maximum use of equipment with less maintenance service because it is cheaper to replace it or its parts than to maintain it for longer use. This is commonly done in such items as components.

The nature of maintenance is service, thus when an organizational structure is drawn in a system equipment it falls under the service section.

After establishing what maintenance is, study will be made of other terms that may be referred to in this manual.

CHAPTER 3 MAINTENANCE MANAGEMENT GUIDANCE FOR O & M WORKS

3.1 General

For the equipment of FFWS to operate stably for a long period of time all equipment must be perfectly/properly maintained. Therefore, maintenance personnel must secure and continuously improve the technology.

To perform the maintenance services, there is a method to prevent future failure by means of periodical inspection. The inspection is the basis of maintenance services which is not only to detect abnormality to avoid failure but also to know the performance of the equipment by recording their operational condition to detect the trouble in advance.

3.2 Maintenance Works and Other Related Works

The inspection works can be classified into the check itself and counter measures will be taken against the result. With preventive maintenance the system down rate, which is very important, must be minimized.

The Maintenance works is grouped into **Inspection**, **Adjustment** and **Repair**.

Inspection is the most basic maintenance; it must not be overlooked to minimize the failure rate of the equipment of FFWS. Therefore, an inspection manual, inspection period, inspection group personnel and checklist, must be prepared.

Adjustment is performed on equipment that has been found to exceed the allowable value by measurement during the time of inspection and must be performed by highly trained engineer or technician.

Repair must be performed immediately after a failure occurs. On site, repair is often difficult where the environment, measuring instruments, power supply, etc. are considered. Repair must be performed by replacing the faulty spare unit with a spare module.

The defective module must be brought back to the master station for repair. This is also to reduce the down time rate of the equipment.

After the inspection, adjustment and repair, the trouble conditions, the repair contents must be recorded in a history logbook as maintenance reference material.

3.2.1 Inspection

(1) Daily Check

Daily check is performed while the system is operating. Each gauging station is subsequently called from the master station the response signal, volume and noise are monitored. The status of each station is grasped by typing out the necessary data. In general, gauging and repeater stations are unmanned and operate automatically.

The checking items are as follow:

- Calling control operation confirmation
- Confirmation of station status and measured data of each station.
- Grasping of response signal level
- Confirmation of data display operation on display panel (applied station only)

This check is performed indirectly by checking the display panel at the master station referring to the followings:

- 1) VOLTAGE DROP on display. Indicator will appear when voltage drop is detected at the gauging station.
- 2) MISSED MEASUREMENT Indicators will appear when the data cannot be received for a long period of time from the gauging station.
- 3) Failure of the operating condition of all equipment are displayed, which monitors the system operating conditions.
- 4) Other necessary items are monitored including necessary measures for preventive maintenance work.

After each check, adjustment or repair it is very important to record the measured values, details of failure, repair done etc. on the logbook. If any abnormalities are detected at daily inspection, they are indicated for recording and prepare inspection items for the next maintenance.

(2) Monthly Check

Physical inspection of each gauging station is performed by hydrologist and telecommunication engineer/technician as a team. The surrounding area must be cleaned. Measured and entered the data at the inspection sheet and simultaneously compared with the data of the previous inspection.

- Inspection and cleaning of station surroundings
- Cleaning of tipping bucket rain gauge
- Inspection of solar cell
- Removal of branches and leaves which obstruct the rain gauge and solar cell
- Inspection of the storage battery
- Calibration of measured value and telemeter transmitted value
- Inspection for loose terminal screws and cables in between equipment
- Ground condition
- Station building
- Sensors.

Faulty points detected by inspection must be improved and repaired quickly.

(3) Quarterly Inspection

Quarterly Inspection is performed simultaneously with the replacement of memory card of the rainfall and water levels at the gauging stations during the condition of the equipment are also checked.

(4) Annual Inspection

Annual Inspection is performed to inspect all equipment and check the station housing surrounding condition especially before the flood season. In addition to the monthly inspection, landslides and other dangerous points around the station housing are considered and measures are taken so that flood can be coped with especially when there is new filling and other landscaping have been performed.

Give careful attention to landslide and changes in the stone walls after heavy rainfall. Highly qualified engineer and technician must perform the inspection. Annual inspection is performed once a year before then onset of rainy season.

The emphasis is given to the system operating condition:

- Inspection and repair of station housing surrounding, banking, stone walls, etc.
- Visual inspection and reinforcing of power lines and other cables.

- Inspection and repair of damage at station housing and surroundings.

(5) Emergency Inspection

Emergency Inspection is performed to check and repair any abnormal conditions around the station housing after typhoons and heavy floods.

Station housing is inspected and reinforced/repared the gauging station where abnormal flood or abnormal rainfall poses a danger.

Emergency inspection on the equipment is necessary and performed during the occurrences of abnormalities.

When equipment, are suspected to be faulty, as judged from the measurement condition, replacement of spare boards and necessary repair is to be perform.

3.2.2 Adjustment

For the general equipment, adjustment is mainly based on the re-adjustment of the input/output level of the equipment to bring them within the specified level.

When the measured items exceed the allowable level during inspection, it must be adjusted to the specified value.

3.2.3 Repair

Since the recovery time is extremely short, adequate repair on site is not always possible when trouble occurs in the telemetry system. Replacement of defective modules/boards on site restores the operational condition of the telemetry system. The defective modules/boards must be brought to H/Q or regional office(s) for repair. When the system contains many the gauging station equipment, for one station should be provided as a spare at the master station. This equipment must be place in the operational state for trouble shooting, training and for testing purposes. Fuses, lamps, etc. are always stocked and kept at the gauging station as spare parts.

After the completion of repair, trouble conditions, trouble point, replaced parts, etc. must be recorded. Moreover, the current stock of spare parts must be grasped, and sufficient parts must always be replenished. Complexity of the equipment is to be expected due to rapid development of electronic equipment. Since this equipment is highly advance in nature it needs technical skill to repair its defective parts.

3.2.4 Measuring/Testing Instruments

To maintain the FFWS equipment in good condition, it is indispensable to be equipped with measuring instruments necessary for the check and repair. The control of the measuring instrument and their periodical calibration are also important tasks to be considered since when failure occurs. Procedure for repair can be prepared in advance and prompt repair can be made.

The following measuring instruments are required **for maintenance of the telemetry/warning** system.

- 1) Signal Generator
- 2) Level Meter with Oscillator
- 3) Portable Engine Generator
- 4) Portable Ohm/Volt/Ampere Tester
- 5) Megger Tester
- 6) Tool Set

CHAPTER 4 PROCEDURES ON OPERATION AND MAINTENANCE

4.1 Function of Operation and Maintenance (O & M) Works

Functions of the O & M works are given as follow:

- 1) Takes charge in the overall operation and maintenance of FFWS and gauging equipment.
- 2) Formulates plans, design and supervise the operation and maintenance of all telecommunication equipment.
- 3) Coordinates closely with the FFWS in matters related to the collection and processing of telemeter rainfall and water level data.
- 4) Collaborates with other related government agencies on the FFWS aspect of the various inter agency flood protection activities.

4.2 General Procedures

The general procedures will be set as follow:

- 1) Travel Order for Routine Maintenance should be provided from the O & M Sections as mentioned below based on the maintenance schedule provided.
- 2) Routine maintenance will be conducted.
- 3) Reports should be submitted by concerned technical personnel.
- 4) All routine maintenance data sheet and reports should be conducted.
- 5) Any technical related problems that might arise in the basin should be the sole responsibility of the concerned technical people to explain thereof.
- 6) Reporting format should be uniform.
- 7) Any emergency, corrective and repair done should be properly documented for future references on maintenance work.
- 8) A meeting is scheduled before and after the maintenance. It composed of the Chief of the relevant section, engineer/technician concerned, and it deals with technical matters, failure and accident report under the operation concerning maintenance work on the telemetry system equipment and facilities.

4.3 Establishment of a Comprehensive O&M Management System

4.3.1 Reports and Organizational Objectives

An organization is any group of people working together to achieve a common goal and purpose. The coordination of activities required is made possible by communication. Communication in general and reports in particular help organizations meet the routine and special objectives necessary to reach long term goals.

4.3.2 Maintenance objectives

Maintenance objectives require routine reports of personnel in-charge as a regular part of the job. Every day and every week a personnel in-charge of the maintenance should submit a report/record on the system condition.

Maintenance reports are periodic reports in nature because they are to be prepared according to a regular time interval (daily, weekly, monthly, quarterly and annually) or even as the need arises. Reports are written to meet maintenance objectives are necessary to monitor and regulate the sustenance of the organization.

4.3.3 Task objectives

The organization must also solve some special problems and meet special objectives. Task reports are necessary to meet these objectives.

4.3.4 Personnel objectives

Personnel who deal with certain operations on a regular basis are often able to foresee problems and suggested improvements. Management can encourage employee to make full use of their creativity and expertise by providing them the opportunity to submit reports anticipating problems or recommending improvements in procedure or service.

4.4 O/M Management Activities

The data collection function has the primary responsibility of moving and conveying data /information. This transfer of information takes place within or between units/agencies for an organization. It is emphasized that data are nothing more than meaningless in numbers/characters; whereas information takes these meaningless numbers/characters and assembles them into a fact or ideas that can be used for FFWS. Information and data are useless if these are not available when needed.

The supervisor of data collection function should always remember that data

and information are transmitted over the system network coming from the gauging station.

Five Key Function of Management Task to be adapted.

Planning Activities

- Establishing objectives
- Scheduling
- Budgeting
- Allocating resources
- Developing policies

Organizing Activities

- Delegating
- Establishment of relationships
- Establishing procedures

Directing Activities

- Initiating activities
- Decision making
- Communicating
- Motivating

Controlling Activities

- Establishing performance standards
- Measuring performance
- Evaluating performance
- Correcting performance

Staffing Activities

- Interviewing people
- Selecting people
- Developing people

In the communication organization, some of the responsibilities and task would be to:

- Plan, organize, direct, control, the entire network operation.
- Acquire knowledge on telecommunication network of FFWS.

- Learn about the total system configuration and its function.
- Plan understand and keep abreast of the latest telecommunication technologies.
- Manage the day-to-day operation of FFWS.
- Manage the maintenance budget of the communication system network with emphasis on controlling the costs.

4.5 Recording and Routine Work in Terms of O & M

4.5.1 Report and Recording

Reports are the principal means by which members of an organization communicate with each other about job related matters. Oral reports are exchanged daily involving a wide variety of maintenance work concerns.

(1) Report

The content of the reports may vary from job to job depending on the nature and purposes of the report each report has particular function or purpose to perform.

(2) Record

The ultimate objective of every record is some kind of action. The most routine maintenance records contain data that will contribute to a decision and analysis of system function/equipment. The maintenance personnel need to see this data/information from time to time on the system operation.

4.5.2 System Failure/Accident Report

This is a report on station to station and system to system operation of a personnel in-charge of maintenance work that monitors through system/equipment when failure/accident occurs and record the incident of failure. This task may be performed by the system operations and or maintenance duty personnel. These personnel are responsible in the scheduling changes, coordination, and follow up of any changes, take over to next duty whether they involve circuits, equipment, or system.

4.6 Repair and Record History

When a repair of trouble or replacement of parts has been done, each case is recorded in the desired form of record for future maintenance reference.

4.7 Routine Maintenance Record

4.7.1 Telemeter equipment

Daily and monthly checks are to be conducted by the data check list method to show the deviations from the fixed standard values. The check results are recorded in the desired forms.

Prior to the flood season every year all the station are to be checked carefully, if anything goes wrong in the system equipment the same shall be fixed to ensure that the system and or equipment is back in operational condition as soon as possible.

4.7.2 Emergency power supply system

If a diesel engine generator is provided.

To maintain the reliability of the entire communication system shall be given special attention. The following preventive maintenance is to be done:

Daily preventive maintenance work as indicated in the check list to be filled up by the personnel on duty. Under the daily specific activities, a series of item check –up must be conducted before, during and after operation.

For the weekly preventive maintenance, most of the activities are intended to find out the condition of the engine generator by checking up its external parts.

For the semi-annual maintenance (6) month interval, the most important feature of this maintenance is the review of the history of engine generator performance. This is an attempt to bring to light any significant variation in the previously recorded characteristics of the engine generator system. For example: increasing fuel consumption may be check against the lubricating oil consumption. The other major items, such as calibration of injection pump, nozzles and engine tune up, are to be checked in accordance with the operation and maintenance manual.

4.7.3 Training and maintenance personnel

Latest technical data or information are to be distributed to the personnel assigned in the maintenance of the telecommunication system equipment as may be considered necessary for the purpose of improving their technical skills and capabilities.

4.8 Methodology of Management and Inventory Control

4.8.1 General

The maintenance workshop is part of the maintenance section. It must perform

a specific function in an organization, and the telecommunication staff should understand the nature of work done. The supervisor must be thoroughly familiar with the office procedures because the orderly conduct and control of the entire operations emanates from the maintenance activities.

4.8.2 Function of Maintenance Section

The maintenance section is the seat of administration for the maintenance work.

Maintenance section performs the following job.

- 1) Plans and schedule maintenance work.
- 2) Assigns job orders to the personnel in-charge of duty.
- 3) Receives work reports and control the maintenance activities.
- 4) Keeps on files relevant records of the system operations (staff, spare parts and equipment control).
- 5) Assists maintenance work by supplying or keeping them informs of parts and material needed.
- 6) Coordinates or relays problems of the system and equipment to higher management levels.

The telecommunication staff is responsible for the proper operations and maintenance; therefore, it is a prime necessity that they are aware always of what is happening in the section and doing their best to perform their duties and responsibilities.

4.8.3 Maintenance Operation

(1) Maintenance Workshop

The maintenance workshop is always involved in any activities of the maintenance work. No work or activities shall be done without the knowledge of the staff in the workshop. The supervisors see to it that the job is done properly, the time and materials are properly utilized.

The progress and completion report of the job is to be rendered through oral and written. Accomplishment report is to be filled up and kept this for future reference. Spare parts are requested as needed. The spare parts records shall show the daily stock position and informs the office that additional parts are to be bought to replenish the stock. This is done to prevent delays in the maintenance and repair works.

(2) Job flow chart

The Flow chart of a job assignment shows the control and the work activities in the maintenance work. The job assignment should be properly filled up by the person concerned in the office. The specific jobs to be done should be written clearly. Detailed description of the work to be done must be recorded.

(3) Work report flow

Work reports are required in a system operation and maintenance to prepare a daily report. This is a good method in checking the work performance of each engineer and technician as it will urge them to complete and report some substantial work and at the same time inform the office about the progress and problems encountered in the maintenance.

(4) Parts/material requisition flow chart

Whenever a certain maintenance work requires some spares the engineer or technician request for them. This part requisitioned goes through a definite route which controls the outflow of these parts. The parts and materials issue card are accomplished by the person in charge with such property. The requisition also serves as record materials requisition issue card, which will require receipt from the engineer when such parts are issued to them. These receipts are properly numbered to keep track of all the receipts. Whenever an item is not available or the receipt is improperly filled up, the receipt should be cancelled and properly put on file for reference.

(5) Purchase order flow chart

The effectiveness of the maintenance and operations depends mostly on the speed of the supply of parts and materials needed for maintenance work. But the parts may not be readily available if a system for its replenishment is not followed. To anticipate these needs parts and materials are requested in advance. The purchased order should clearly specify the parts or materials needed in order that the cost estimate is made, and the purchaser will be properly guided.

(6) Parts and material record

As soon as the spare parts are delivered the person in charge have to

control the outflow of the materials. Proper records must indicate where and what maintenance works these items was used. This is recorded in the materials requisition issue cards for each work. The person in charge of parts control records all parts and materials in the stock card for each item.

Data base management system for spare parts/material records was started and under construction. If the system is declared to be effective, then it is the time to print records and put them on hard copy for filling. The entries made on the data base show a diminishing quantity from the time of parts was used and purchased. The stock balance appearing on each corresponding date is on the stock position. Stock position means the record parts and materials available on hand.

4.8.4 Inventory Control

An inventory control is a detailed checking of all spare parts/materials by examining the records and comparing it with those existing on hand.

Its purposes are.

- 1) To determine and review the present quantity of spare parts and materials.
- 2) To classify all spare parts materials according to their present condition and whereabouts.

There are two (2) common inventory practices which the group may adopt.

(1) Unscheduled spare parts/materials check

This is conducted anytime the supervisors feel the need to make an on-the-job-spot check of the spare parts materials and make a physical inventory. The common practice is to make a quick comparison between the record and the existing items.

(2) Scheduled inventory

This is a general inventory control system. The following are the practical inventory method:

(a) Records inventory

This is a close examination of spare/parts materials records in order to determine the number of spare parts/materials as reflected in the records.

(b) Record book inventory

A record book inventory may be done before or after the physical count.

(c) Physical inventory

This is an actual count of all spare parts/materials are to ascertain their whereabouts and conditions. Usually, this is also a time when all spare parts/materials are classified as obsolete, damaged, phased out or replaced. Newly purchased items must also be recorded.

4.9 Methodology of Test Instruments and Tool Control

4.9.1 General

The supervisor, engineer or technician under him needs to be familiar with the different types of test instrument and tools in the maintenance work. There is no better indication that the engineer and technician know their trade other than their accurate knowledge of the many test instrument/tools and their correct application to produce good workmanship. For the supervisor, he must see to it that reduced manpower cost and high work quality must be maintained to put the system operating.

4.9.2 Calibration of Instruments

The test instrument considered necessary for maintenance of telecommunication system/equipment are provided in accordance with the principles. To keep accurate measuring system of the telecommunication equipment, all test instruments need calibration at periodical time interval because of error prone after considerable usage. In most case, calibration is conducted every (6) six months.

4.9.3 Preparation of Application Library

To build up technical knowledge for the maintenance personnel and to establish the standard maintenance procedure of the system/equipment standard application of the test circuit is to be prepared.

4.9.4 Test Instrument and Tools Arrangement

To keep effective system operation and maintenance of the system/equipment, test instrument and tools should be properly arranged.

Guidelines:

- 1) Keep tools and instrument clean
- 2) Place tools and instrument including test cables always in proper location.

- 3) Arrange all tools and instrument to provide maximum safety.

4.10 Vehicles Maintenance and Operation

4.10.1 Maintenance and Responsibility

The maintenance personnel and driver shall maintain well the assigned vehicle under his responsibilities in the following manner:

- 1) Daily routine checkup before starting to drive.
- 2) The vehicle is always kept clean (inside/outside) and properly waxed at least once a month.
- 3) Any damage in the daily checkup should be repaired immediately.

4.10.2 Safety Driving

- 1) Take suitable route for the safety of the maintenance personnel.
- 2) Take safety precaution when driving and be defensive.
- 3) Driving rules and regulation must be followed.

4.11 Refence Documents

There are listed for the reference documents for reliable and sustainable O&M works as a sample.

- 1) Current Status of the Equipment: Form No. 1
- 2) Check List: Form No. 2
- 3) Repairing Record of Trouble/Failure of the Equipment: Form No. 3
- 4) Spare Parts List: Form No. 4
- 5) Reference Manuals prepared by the vendors

As of xxxx, 2024

[illegible]

Legends

RG: Rainfall Gauge. WL: Water Level gauge.

Notes

*1: The equipment were manufactured in October 2012

Check List for Equipemnt for FFWS
Place: Gauging Ste

Form No. 2

Check all items at 3/6 months regular maintenance
Clean inside of the Equipment
Check surrounding Conditions

Year:

Month:

Conducted by

Equipment	Item to be checked	Criteria	Data/Result	Remark
Water Level Sensor	Appearance Inspection			
	Cleaning			
Rainfall gauge	Appearance Inspection			
	Cleaning			
	Mechanism Inspection			
Telemetry equipemnt	Power Voltage Check	DC 10 - 15 V		
	Input Data Checking			
	Arrester Checking			
Solar Power Supply Equipment	Physical Damage Checking			
	Connectors and Terminals Checking			
	Cleaning of Surface of Solar Array			
	Performance Checking - Voltmeter/Ammeter - Checking Surge absorbers - LED Indicators of Charge Controller			
	Battery Voltage	DC 9.6 to 14.5 V		

Legend

N: Normal

A: Abnormal

U: Under repairing

Repairing Record of Trouble/Failure of the Equipment

Date: _____

Reported by: _____

Station name: _____

Equipemnt name _____

Model: _____

Serial No.: _____

1. Aspect of Trouble/Failure

2. Cause of Trouble/Failure

3. Remedy

Spare Parts Lists

Category: Telemetry equipment

[illegible]

Appendix 17

Monitoring Sheet

Project Monitoring Sheet at the beginning of the Project in July 2021**Project Title: Kenya Water Resources Advisor****Implementing Agency: Water Resources Authority (WRA)****Target Group: Staff of WRA Headquarters (HQ) and Tana Regional Office (RO)****Period of Project: From April 2021 to April 2024 (36 months)****Project Site: WRA HQ and Tana RO****Version 0****Dated July 06, 2021**

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption	Achievement	Remarks
Overall Goal					
Strengthening of WRA's Capacity on Hydrological Data Management (Monitoring/Observation, Arrangement, Storage, Analysis and Utilization)	Staff of WRA are able to manage Hydrological Data through: 1) Monitoring/Observation, 2) Arrangement, 3) Storage, 4) Analysis, and 5) Utilization.	Through interactions with WRA staff in charge, JICA Experts Team evaluate capacity of relevant WRA staff on designate outputs and activities as metioned in Outputs.			
Project Purpose					
To improve skills of WRA staff aiming at realizing strengthening of water resources management capacity. Those skills improvement includes: 1. Strengthening of monitoring network. 2. Improvement and fixation of capacities related to data monitoring, 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.	Improvement of WRA staff skills in terms of: 1) Adequacy, 2) Effectiveness, 3) Efficiency, 4) Impact, and 5) Self-Sustainability (* The above five items are referred to from the JICA Guidelines of Project Evaluation.)	Verify relevant indicators as shown left (Nos. 1) to 5)) with the following means: Item "1. Strengthening of monitoring network" is verified by evaluation of the result of "Output 1: Hydrological Monitoring Network Update in accordance with the Purpose of Observation." Item "2. Improvement and fixation of capacities related to data monitoring, arrangement, storage, and analysis" is verified by evaluation of the result of "Output 2," "Output 3," and "Output 4." Item "3. Utilization of observed results which are required for solutions of water resources related issues such as Flood, Drought, and Climate Change" is verified by evaluation of the result of "Output 4: Capacity Building on Analysis and Utilization of Hydrological and Meteorological Data."	- Required budget is secured for WRA staff to participate in activities for improvement of skills. - Required budget is allocated for operation and maintenance of the existing monitoring stations. - Trained WRA staff are not transferred to other posts during the Project Period.		

Outputs 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. Activity 1-3: Clarification on 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.	Status of each activity	Whether each activity is: 1) CO: Completed, 2) OG: On-going, or 3) NY: Not yet started, with narrative descriptions of the results, issues, status. Activity 1-1: OG (Jun. 2021 - Mar. 2022) Activity 1-2: OG (Jun. 2021 - Nov. 2023) Activity 1-3: NY (Oct. 2021 - Mar. 2022) Activity 1-4: NY (Feb. 2022 - Jul. 2022)	The same as above.		
Output 2 Capacity Building on Hydrological Monitoring Activity 2-1: Confirmation on operational status and analysis of issues on Observation 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 Observation at site including preparation of H-Q Curve	Status of each activity	Whether each activity is: 1) CO: Completed, 2) OG: On-going, or 3) NY: Not yet started, with narrative descriptions of the results, issues, status. Activity 2-1: OG (Jun. 2021 - Nov. 2021) Activity 2-2: NY (Oct. 2021 - Mar. 2022) Activity 2-3: NY (Feb. 2022 - Jul. 2022) Activity 2-4: NY (Jun. 2022 - Nov. 2022)	The same as above.		
Output 3 Capacity Building on Arrangement and Storage of Hydrological and Meteorological Data Activity 3-1: Quality Improvement Guidance and Preparation of Quality Control Standard Activity 3-2: Confirmation on the Current Status and Improvement on Operation and Management of Database	Status of each activity	Whether each activity is: 1) CO: Completed, 2) OG: On-going, or 3) NY: Not yet started, with narrative descriptions of the results, issues, status. Activity 3-1: NY (Oct. 2022 - Mar. 2023) Activity 3-2: NY (Feb. 2023 - Jul. 2023)	The same as above.		

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 Climate Change Affect Activity 4-3: Discussion and Compilation on the Function of WRA as well as Utilization of Monitoring Results aiming at Flood Damage Mitigation Activity 4-4: Discussion and Compilation on the Measures during Droughts as well as Utilization and Analysis of Monitoring Results Activity 4-5: Publication and Notification to Related Organizations on the Hydrological and Meteorological Data	Status of each activity	Whether each activity is: 1) CO: Completed, 2) OG: On-going, or 3) NY: Not yet started, with narrative descriptions of the results, issues, status. Activity 4-1: NY (Feb. 2022 - Jul. 2022) Activity 4-2: NY (Jun. 2022 - Jul. 2023) Activity 4-3: NY (Feb. 2023 - Nov. 2023) Activity 4-4: NY (Jun. 2023 - Nov. 2023) Activity 4-5: NY (Oct. 2023 - Nov. 2023)	The same as above.		
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Activities	Inputs		Pre-Conditions
Output 1 Hydrological Monitoring Network Update 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. Activity 1-3: Clarification on 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. Output 2 Capacity Building on Hydrological Monitoring Activity 2-1: Confirmation on operational status and analysis of issues on Observation 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 Observation 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 Standard 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 Climate Change Affect Activity 4-3: Discussion and Compilation on the Function of WRA as well as Utilization of Monitoring Results aiming at Flood Damage Mitigation Activity 4-4: Discussion and Compilation on the Measures during Droughts as well as Utilization and Analysis of Monitoring Results Activity 4-5: Publication and Notification to Related Organizations on the Hydrological and Meteorological Data	The Japanese Side	The Kenyan Side	- Newly developed standards/ guidelines are approved by WRA and disseminated to other regions. - Trained WRA staff are not to be transferred to other positions during the Project Period. - Security conditions do not deteriorate Project Activities.
	1. JICA Experts (1) Team Leader/Water Resources Management (2) Hydrological Monitoring/Flood and Drought Risk Assessment (3) Telecommunication/Innovation Technology 2 Equipment After checking the current situation, procurement will be made. 3. Local Supporting Staff (1) Co-Team Leader/Water Resources Management (2) Hydrological Monitoring (3) COmmunication System (4) Public Relations (5) Secretary 3. Local Subcontract (1) River Cross-section Survey (2) Discharge Measurement	1. WRA counterpart staff - WRA Headquarters (1) HQ Technical Manager (2) HQ Surface Water (SW) Officer (3) HQ Data Management Officer - Embu Regional Office (RO) (4) Embu RO Manager (5) SW Officer - Garissa Sub-Regiona Office (SRO) (6) SRO Manager (7) SW Officer - Meru SRO (8) SRO Manager (9) SW Officer - Kerugoya SRO (10) SRO Manager (11) SW Officer - Muranga SRO (12) SRO Manager (13) SW Officer - Kitui SRO (*) (14) SRO Manager (*) There is no SW Officer in Kitui SRO as there is no perenial river in Kitui SRO.	
			<Issues and countermeasures>

Project Monitoring Sheet at the completion of the Project in October 2024

Project Title: Kenya Water Resources Advisor

Implementing Agency: Water Resources Authority (WRA)

Target Group: Staff of WRA Headquarters (HQ) and Tana Regional Office (RO)

Period of Project: From April 2021 to Oct 2024 (42 months)

Project Site: WRA HQ and Tana RO

Version 6

Dated October 29, 2024

Native Summary	Objectively Verifiable	Means of Verification	Important Assumption	Achievement	Remarks
Overall Goal Strengthening of WRA's Capacity on Hydrological Data Management (Monitoring/Observation, Arrangement, Storage Analysis and Utilization)	Staff of WRA are able to manage Hydrological Data through: 1) Monitoring/Ob 2) Arrangement, 3) Storage 4) Analysis, and 5) Utilization.	Through interactions with WRA staff in charge, JICA Experts Team evaluate capacity of relevant WRA staff on designate outputs and activities as mentioned in Outputs.	Required WRA staff available to participate in activities for improvement of skills.	Overall goal achieved on number of staff trained on all aspects identified under the activities. Hydrological Data Management on Monitoring/Observation, Arrangement, Storage Analysis and Utilization.	Ensure collaboration among stakeholders for accurate data collection
Project Purpose To improve skills of WRA staff aiming at realizing strengthening of water resources management capacity. Those skills improvement includes: 1. Strengthening of monitoring network. 2. Improvement and fixation of capacities related to data monitoring, 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.	Improvement of WRA staff skills in terms of: 1) Adequacy, 2) Effectiveness, 3) Efficiency, 4) Impact, and 5) Self-Sustainability (* The above five items are referred to from the JICA Guidelines of Project Evaluation.)	Verify relevant indicators as shown left (Nos.1- 5)) with the following means: Item" 1. Strengthening of monitoring network "is verified by evaluation of the result of "Output 1: Hydrological Monitoring Network Update in accordance with the Purpose of Observation." Item "2. Improvement and fixation of capacities related to data monitoring, arrangement, storage, and analysis" is verified by evaluation of the result of "Output 2, "" Output 3" and "Output 4." Item "3. Utilization of observed results which are required for solutions of water resources related issues such as Flood, Drought, and Climate Change" is verified by evaluation of the result of "Output 4: Capacity Building on Analysis and Utilization of Hydrological and Meteorological Data."	Required budget is secured for WRA staff to participate in activities for improvement of skills. Required budget is allocated for operation and maintenance of the existing monitoring stations. Trained WRA staff are not transferred to other posts during the Project Period. Availability of required staffing at regional and HQ	15-18 staff comprising Surface water Officers, Sub Regional Managers (SROs, SWO)- from Meru, Kerugoya, Murang'a, Tiva & Garissa trained Monitoring Stations such as 4F10 cross sectional survey conducted. Number stations upgraded and monitored	New tariff proposed in the next financial year by five folds thus WRA will be well resourced to perform its mandate

Native Summary	Objectively Verifiable	Means of Verification	Important Assumption	Achievement	Remarks
Outputs					
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. Activity 1-3: Clarification on 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.	Collect comprehensive data on flood and drought impacts and countermeasures. Identify gaps and opportunities for collaboration. Optimize the monitoring network for risk evaluation. Enhance data utilization for effective water management	Activity 1-1: CO (Jun. 2021 – September 2024)-Survey of flood & Drought documented with key stakeholders identified. Training on alternative flood early warning System and mitigation using RRI combined with other digital models. Activity 1-2: CO (Jun. 2021 – April. 2024) Support partners' identification from the key stakeholder with activities on water resources. Survey findings, partnership agreements Activity 1-3: CO (Oct. 2021- May. 2023) SW stations identified, referenced, under management unit. Purpose of stations partly identified based on ICS report and SROs interview. Station evaluation matrix and progress reports. Activity 1-4: CO (Feb. 2023- Jul. 2024) Updated monitoring plan, utilization reports, critical stations identified. Sample stations of Maragua and Ragati with many water permits.	Accessibility to affected areas and availability of reliable data. Information on drought and floods is accurately reported from sources. Required information is provided by stakeholders and timely. Information sort will be readily available. Information provided by WRA is up to date (field verification may be necessary). Existing monitoring plans are understood and utilized and WRA	Comprehensive data collected and analyzed from affected areas. Key stakeholders Identified and support to WRA identified avoiding duplication. Identified key areas for collaboration and potential partners Strategic positioning of observation stations for effective risk evaluation. Strategic positioning of observation stations for effective risk evaluations Water stations status updated	Ensure collaboration with local authorities for accurate data collection. Engage in regular communication with development partners. Continuous review and adjustment of station positions based on new data Regular follow-ups and assessments to ensure plan effectiveness. Consider implementing Stations identified under the water Masterplan and KWSCRIP. Telemetry station vandalism reported but mitigated through alternative setups.

Native Summary	Objectively Verifiable	Means of Verification	Important Assumption	Achievement	Remarks
Output 2 Capacity Building on Hydrological Monitoring Activity 2-1: Confirmation on operational status and analysis of issues on Observation 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 Observation at site including preparation of H-Q Curve	Ensure the functionality and reliability of monitoring infrastructure. Establish efficient data transmission processes. Enhance technical skills of WRA staff. Improve accuracy and reliability of field data Increased capacity in hydrological data transmission and observation	Activity 2-1: CO (Jun. 2021 – July. 2024) Status reports, issue logs Activity 2-2: CO (Oct. 2022 – June 2024) Operational plans, feedback reports Activity 2-3: CO (Feb. 2023- July 2024) Training materials, Minutes, Questionnaires, attendance records, feedback forms. Activity 2-4: CO (Jun. 2022- Mar. 2024) Training records, H-Q curves, field reports, improved accuracy and reliability of field data.	Cooperation from WRA management and respective staff seconded in the project. WRA staff to participate in activities for improvement of skills. Trained WRA staff not transferred to other positions during the Project Period. Resources available to carry out the activities	The team prepared the Training Material for Hydrological Monitoring and holding a wrap up session for it on 14 Feb 2014. MS-Excel sheet for Semi-automatic prepared and shared during the capacity building exercises. Multiple training sessions conducted on data transmission, MIKE Workbench, and SEBA Telemetry system H-Q Curve were developed through classroom exercises and presentations. Improved accuracy and reliability of field data through enhanced skills Established quality control standards and guidelines ensuring high-quality data management	Timely maintenance and troubleshooting Regular updates to the operation plan based on performance reviews. Schedule refresher training sessions periodically. Continuous skill enhancement programs Telemetry station vandalism reported but mitigated through alternative setups.

Native Summary	Objectively Verifiable	Means of Verification	Important Assumption	Achievement	Remarks
Output 3 Capacity Building on Arrangement and Storage of Hydrological and Meteorological Data Activity 3-1: Quality Improvement Guidance and Preparation of Quality Control Standard Activity 3-2: Confirmation on the Current Status and Improvement on Operation and Management of Database	Ensure high-quality data management practices. Optimize database operations and management	Activity 3-1: CO (Oct. 2023 – Aug. 2024) Data quality improvement and improved data management practices Activity 3-2: CO (Feb. 2023 – May. 2024) Optimization of database operations and management.	Quality Check during gauge readings. However, there is no quality control standards for telemetric data. Current database operation methods may be different from 2019, when the previous Guideline was created. Access to modern database systems and regular staff participation	Improved database operations and management system Enhanced analytical capabilities through effective training	Regular quality audits and feedback mechanisms. Ongoing system evaluations and upgrades.
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 of Climate Change effects. Activity 4-3: Discussion and Compilation on the Function of WRA as well as Utilization of Monitoring Results aiming at Flood Damage Mitigation Activity 4-4: Discussion and Compilation on the Measures during Droughts as well as Utilization and Analysis of Monitoring Results. Activity 4-5: Publication and Notification to Related Organizations on the Hydrological and Meteorological Data	Enhance analytical capabilities of WRA staff. Develop strategies to mitigate climate change effects. WRA's staff capacity strengthened on flood mitigation efforts. Improvement on drought response and management Promotion of informed decision-making	Whether each activity is: 1) CO: Completed 2) OG: On-going, or 3) NY: Not yet started, with narrative descriptions of the results, issues, status. Activity 4-1: CO (Feb. 2022 – May. 2024) Enhance analytical capabilities of WRA staff on specific use of training received at the regional offices in Embu, field and online trainings. Activity 4-2: CO (Jun. 2022 – May. 2024) Understanding of Climate change, developed strategies to mitigate climate change effects. Activity 4-3: CO (Feb. 2023- May.2024). Minutes of discussions, evaluation report and developed mitigation strategies. Activity 4-4: CO (Jun. 2023- May. 2024) Verification with compiled reports, with mitigation measures Activity 4-5: CO (September 2024),	Staff understanding of analysis techniques Access to relevant climate data Engagement of all relevant stakeholders. Continuous access to high-quality climate and hydrological data Support from stakeholders for implementing measures Stakeholder participation and understanding each role. Feedback received from stakeholders were documented	Achievement measured based on developed strategic plans to mitigate climate change effects Strengthened WRA's role and strategies in flood mitigation. 1no. training session on Climate Change conducted in Embu, its impact and monitoring. At the end of the activity, effective drought mitigation measures were identified for implementation. Timely and successfully shared data, improving decision-making.	Encourage practical application of analysis skills Current database operation methods may be different from 2019, when the previous Guideline was created. Integrate findings to include broader water management strategies Regular review and update of mitigation strategies Continuous monitoring and adaptation of measures Establish data sharing protocols

Native Summary	Objectively Verifiable	Means of Verification	Important Assumption	Achievement	Remarks
		Two Seminars were conducted in Nairobi and Embu on 17 th and 19 th September 2024 respectively.			

Inputs

Activities	Inputs		Pre-Conditions
Output 1 Hydrological Monitoring Network Update 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. Activity 1-3: Clarification on 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.	The Japanese Side 1.JICA Experts (1) Team Leader/Water Resources Management (2) Hydrological Monitoring/Flood and Drought Risk Assessment (3) Telecommunication/ innovation Technology 2.Equipment After checking the current situation, procurement will be made. 3.Local Supporting Staff (1) Co-Team Leader/Water Resources Management (2) Hydrological Monitoring (3) Communication System (4) Public Relations (5) Secretary 4. Local Subcontract (1) River Cross section Survey (2) Discharge Measurement	The Kenyan Side 1.WRA counterpart staff - WRA Headquarters (1) HQ Technical Manager (2) HQ Surface Water (SW) Officer (3) HQ Data Management Officer - Embu Regional Office (RO) (4) Embu RO Manager (5) SW Officer - Garissa Sub-Regional Office (SRO) (6) SRO Manager (7) SW Officer - Meru SRO (8) SRO Manager (9) SW Officer - Kerugoya SRO (10) SRO Manager (11) SW Officer - Murang'a SRO (12) SRO Manager (13) SW Officer - Kitui SRO (*) (14) SRO Manager (*) There is no SW Officer in Kitui SRO as there is no perennial river in Kitui SRO.	-Newly development standards/guidelines are approved by WRA and disseminated to other regions. -Trained WRA staff are not to be transferred to other positions during the Project Period. -Security conditions do not deteriorate Project Activities

Activities	Inputs		Pre-Conditions
Output 3 Capacity Building on Arrangement and Storage of Hydrological and Meteorological Data Activity 3-1: Quality Improvement Guidance and Preparation of Quality Control Standard 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 Climate Change Affect Activity 4-3: Discussion and Compilation on the Function o WRA as well as Utilization o Monitoring Results aiming at Flood Damage Mitigation Activity 4-4: Discussion and Compilation on the Measures during Droughts as well as Utilization and Analysis of Monitoring Results Activity 4-5: Publication and Notification to Related Organizations on the Hydrological and Meteorological Data			

Appendix 18

**Items/Equipment to be Handed over from
the JICA KWRA Project to WRA**

ITEMS/EQUIPMENTS TO BE HANDED OVER FROM JICA KWRA PROJECT 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	

ITEMS TO HANDOVER TO WRA

1. LCD PROJECTOR



2. DIGITAL CAMERA



3. COLOR PRINTER



4. WIFI ROUTER



5. WIFI POCKET ROUTERS (HUAWEI BRAND)



5. WIFI POCKET ROUTER (ALCATEL BRAND)



6. NOTE PC



7. PC MONITOR



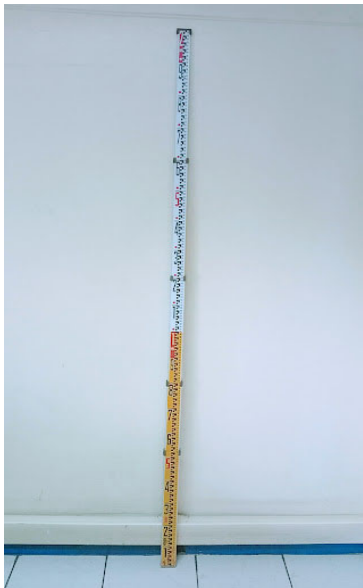
8. CONFERENCE SPEAKER AND MICROPHONE



9. WATERPROOF WADER SUITS (1st FROM THE LEFT IS COLOUR GREEN & 2nd IS BLACK)



10. ALUMINIUM LEVEL STAFF



11. ANCHORAGE ROPE (50 M)

