JICA PROJECT BRIEF NOTE

Kenya:
Project for Strengthening Capacity in Non-Revenue Water Management

NRW management based on realistic NRW reduction plan and organizational capacity for expanding NRW reduction activities in Kenya

Version 2, June 2020

Setting up an ultrasonic flow meter (Eldoret WSP)

1. Project Background and Challenges

1.1 Importance of reducing NRW in Kenya

Approximately 80% of the landmass in the Republic of Kenya (Kenya) is arid or semi-arid. There is a concern that the amount of available water per capita will decline as the water demand increases with the country's population growth. For effective use of water resources, the Government of Kenya (GoK) set reduction of Non-Revenue Water (NRW) as a national priority, and aims to reduce the annual average NRW ratio to 20% by 2030.

According to the Impact Report issued annually by the Water Services Regulatory Board (WASREB) under the Ministry of Water, Sanitation & Irrigation (MWS&I), the national average NRW ratio in 2015 was about 42%, having gradually declined from 60% in 2010. Nevertheless, achieving the national target of NRW ratio below 20% indicated in Vision 2030 will require further efforts. To tackle this challenge, JICA launched the "Project for Strengthening Capacity in NRW Management" (hereafter, the Project). The Project aims at strengthening the skills and capacity of Water Service Providers (WSPs) to formulate and implement realistic NRW reduction plans and at strengthening the capacity of organizations that support WSPs in NRW reduction.

The Project implementation period is from October 2016 to September 2021, a duration of five years.

1.2 Project Counterparts

The Project's counterparts (C/P) are: MWS&I NRW Management Unit (the NRW Unit) established in 2016 to lead and coordinate the national efforts of NRW reduction; WASREB, Kenya Water Institute (KEWI), and the Water Service Providers Association (WASPA). Meru and Embu WSPs, previously supported by JICA's projects, are positioned as leading WSPs. Additionally, seven WSPs were selected from the results of a baseline study conducted at the beginning of the Project, making the total to nine pilot WSPs (Table 1).

Table 1: Pilot WSPs and project phases

Project Phase	Pilot WSP
Phase 1 & 2	Meru, Embu (as Leading WSPs)
Phase 2	Kisumu, Nakuru, Nyahururu, Ruiru-Juja
Phase 3	Eldoret, Kilifi-Mariakani, Mavoko

1.3 Project framework and implementation structure

Figure 1 shows the Project's overall goal, purpose, outputs, and C/P organizations. The implementation of the project is from October 2016 to September 2021 (for five years) in the following three phases:

Phase 1 : October 2016 to September 2017
Phase 2 : October 2017 to September 2019
Phase 3 : October 2019 to September 2021

The Project Implementation Committee (PIC) is comprised of the C/P organizations' representatives and meets once a month. At the PIC meetings, the progress of the activities is shared and issues related to the Project implementation are discussed. The Joint Coordinating Committee (JCC) meets twice a year. JCC approves the project work plans, revision of the project schedule, and monitors the implementation of activities and achievements.

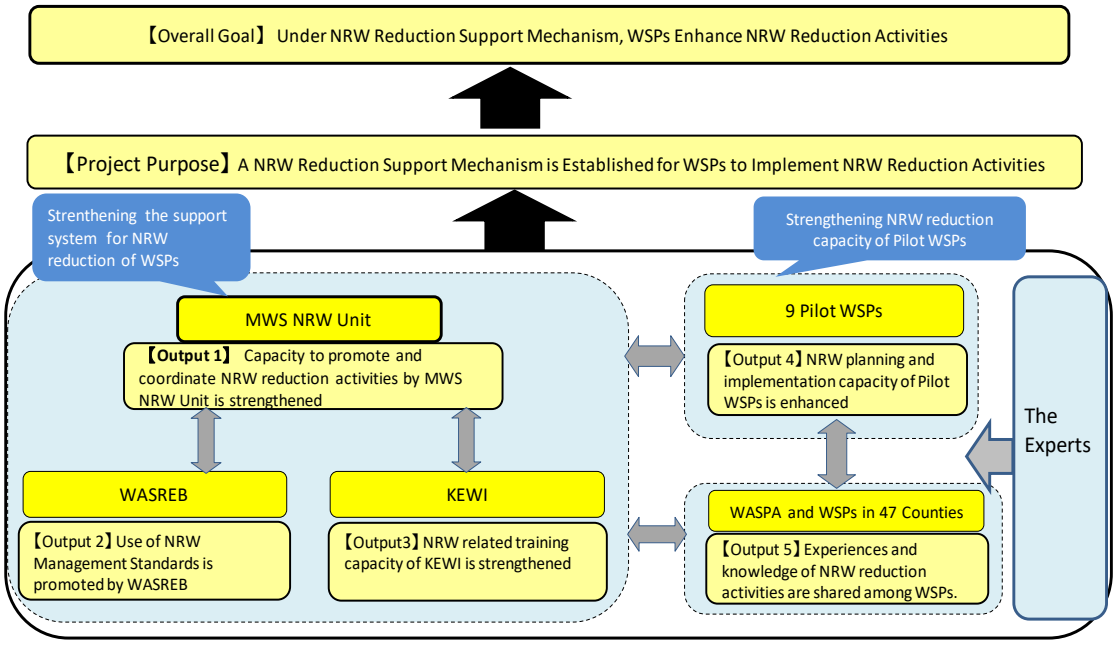


Figure 1. Project purpose, outputs and counterpart organizations

2. Project Approach to Tackle the Challenges

2.1 Project approach based on the baseline results

Based on the results of the baseline study, the Project identified the challenges of each C/P and set up the following approaches and activities.

2.1.1 Ministry of Water, Sanitation & Irrigation （Output 1）

The mandate of the NRW Unit is to formulate policy and regulations for NRW reduction, and coordinate and implement NRW reduction campaigns nationally. As the NRW Unit was newly formed in the MWS&I in Feb. 2016, the Unit officers do not have much experience on NRW reduction activities. By implementing the Project activities, the officers can gain experience and strengthen the capacity of the Unit. In Output 1, the Project aims at promoting NRW reduction sensitization activities and, monitoring of WASREB and KEWI activities. Through the implementation of these activities, the NRW Unit staff will be able to lead NRW reduction activities at the national level.

2.1.2 WASREB (Output 2)

WASREB's project activity is to revise and promote the NRW Management Standards (hereafter, the Standards) which were developed in the previous JICA project[1] in 2014 to provide technical guidance for NRW reduction. The Standards comprise four volumes: Guidelines, Manual, Handbook, and Case Studies. Due to changes in administration of water services and the knowledge and experience of WSPs, the contents of the Standards were considered not fit for the current situation. Therefore, WASREB conducted a study on the usage of the Standards, and from the results they decided to revise it and then promote the use of revised Standards.

2.1.3 KEWI （Output 3）

KEWI is the only public educational institution for technicians in water and sewage services and water resources development in Kenya. KEWI has been conducting a NRW short training course developed by the previous JICA project as part of the regular training program. The results of the baseline study were that the short training course focused on theory-based lectures while the practical training was limited to the operation of equipment and site tours of the water facilities; which did not match the training needs of WSPs. In addition, lecturers of the training course lacked motivation to self-

[1] JICA NRW management project (2010-2014)

improve their teaching skills, and only repeated the existing lectures. Together with the lecturers, the Project reviewed and revised/improved the contents of the existing NRW short course, the teaching materials, and the method and practice of teaching with the intention of strengthening the training capacity of KEWI. Furthermore, the training reformed as a new NRW practitioner's short course with field practical in collaboration with the leading WSPs such as Meru and Embu WSPs.

2.1.4 Pilot Water Service Providers (Output 4)

Based on the baseline study, the Project identified issues causing NRW for each pilot WSP and approaches to tackle the identified issues chosen, and implemented them. From the activities conducted so far, the following approaches are considered as effective to strengthen the technical skills of NRW reduction.

1. Implementing activities targeting entire service areas

In order to reduce NRW quickly, the Project has been supporting the pilot WSPs in implementing their basic NRW reduction activities covering their entire service area (such as identifying unbilled customers, maintaining the accuracy of large customers' meters, scouting for visible leaks, and standardizing service connections). As a result, five pilot WSPs (Kisumu, Nakuru, Nyahururu, Ruiru-Juja, and Eldoret) have significantly reduced NRW by more than 10% (as at the end of Phase 2). Meanwhile, leak reduction activities such as leak detection and pressure reduction have been conducted first in distribution zones or District Metered Areas (DMAs) selected or hydraulically isolated as pilot areas, before being expanded to other areas (taking into consideration the results from the pilot areas). This approach to leak reduction in pilot areas seems effective to some extent.

Meter accuracy test using calibrated bucket and portable meter tester (Ruiru-Juja WSP)

2. Promoting self-motivated organizational strengthening or restructuring

The Project has guided the pilot WSPs through some activities that require the involvement of the entire WSP or its multiple departments (e.g. analyzing the frequency of using estimated consumption for billing due to faulty meters, etc., and formulating annual NRW reduction plans based on capacity self-assessment). Through these activities, the Project encouraged WSPs to strengthen their organizational structures and internal communication (e.g., by engaging the commercial department in NRW reduction activities, and increasing the number of NRW section/unit staff). As a result, four WSPs (Embu, Kisumu, Nakuru and Eldoret) have successfully strengthened their organizational structures for NRW reduction and restructuring of two WSPs (Ruiru-Juja and Kilifi-Mariakani) is in progress.

3. Securing the credibility of universal NRW ratio

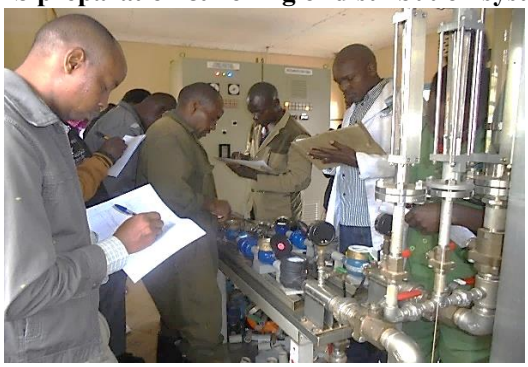
In Kenya, most of the WSPs' bulk meters used to calculate their universal NRW ratios are often not functional, hence WSPs repeatedly use estimated monthly water flow instead of measured flow. In these cases, accuracy of performance indicators such as amount of supplied water, NRW volume and NRW ratio are compromised. In addition, monthly NRW ratio may abnormally fluctuate on a seasonal basis due to faulty bulk meters. For example, during the dry season when water supply often increases, if a WSP estimates the monthly flow at a faulty bulk meter by calculating their average monthly flow for previous year or the few months prior to becoming faulty, the monthly NRW ratio during the dry season would be significantly underestimated. Therefore, fluctuations of monthly NRW ratio and other key performance indicators over the previous few years have been analyzed to identify abnormal fluctuations of NRW ratio, etc. As a result, in Embu WSP for example, a production meter essential for measuring the total amount of water supplied was found to be faulty. This was dealt with by installing additional bulk meters. Similar improvements are ongoing in Meru and Kilifi-Mariakani WSP.

4. Formulation of NRW reduction plan based on capacity self-assessment

The pilot WSPs have been preparing their medium-term (5 years) and annual NRW reduction plans every year for the last 3 years (since the beginning of the Project). However, assessment of their current capacity for

formulating efficient plans was found to be insufficient. To tackle this, the Project formulated a checklist of 33 NRW-related aspects (containing approx. 250 checkpoints in total and average eight check points per aspect) and integrated them into an MS Excel template to enhance WSPs' capacity for self-assessment (Figure 3). The results of this comprehensive self-assessment (through the template) are automatically displayed in a graph. Using this, WSPs can then compare the results of the assessment with the NRW guidelines by themselves.

5. GIS preparation & zoning of distribution systems



KEWI's practical training at Embu WSP

At the beginning of the Project, six pilot WSPs already had Geographic Information Systems (GIS) to manage water supply pipes and customer meters, etc. The Project has been supporting these WSPs to efficiently update and further utilize their GIS data. For the remaining three pilot WSPs, the Project has been supporting their development of GIS databases from scratch (e.g. setting up free high-resolution satellite imagery as a base map). Two WSPs are already using their newly developed GIS databases for NRW reduction activities.

In some pilot WSPs, their distribution systems are divided by administrative borders, which often makes it difficult to realize effective NRW management over distribution networks. To improve this situation, the Project has been promoting separation of the existing distribution systems (entire service areas) into hydraulic distribution zones (and further into DMAs when required). Already, seven WSPs have developed their zoning plans using GIS. Based on the plans, the distribution networks are gradually being separated into hydraulic zones.

Meanwhile, the mixture of areas of continuous water supply and areas of intermittent supply within the service areas of each WSP makes technical assistance on leak detection more challenging due to the differing skills required depending on the supply conditions. This mixture also makes it difficult for WSPs to determine how to expand leak detection activities over their entire service area in future. Therefore, at three pilot WSPs so far, continuous and intermittent supply areas have been identified and mapped on their GIS in addition to their hydraulic zoning plans, in order to formulate suitable leak detection techniques and determine how to expand their leak detection activities over their service areas (Figure 4). With this kind of support, the ongoing on-job-training (OJT) on leak detection methods is expected to deliver more sustainable and expandable results.

6. Monitoring of progress in NRW reduction

Generally, Kenya's WSPs' NRW ratio seasonally fluctuates significantly, which makes it difficult to understand the effects of the implemented NRW reduction activities and its effectiveness by just looking at the changes in NRW ratio over the last few months. In order to distinguish the effects of NRW reduction activities from seasonal fluctuations, the Project has been supporting the WSPs to analyze seven monthly indicators over the last three years, display their past fluctuation trends on the same graph, and monitor them continuously (by updating the graph monthly). The seven indicators are; monthly supplied amount (m^3/month), billed consumption (m^3/month), billed water charges (Ksh/month); and four more indicators calculated from these three data. WSPs are expected to share the results of the updated graph at their inter-departmental monthly meetings to collectively discuss the effects and problems of the implemented NRW reduction activities and further improve the activities.

7. Measures against commercial water losses

At each pilot WSP, the Project analyzed the monthly meter reading and billing data of all the customers (for 12 or more months) to determine the frequency of using estimated consumptions for billing. Billing based on estimates was most frequent at Ruiru-Juja WSP among the pilot WSPs. After this analysis, Ruiru-Juja increased the number of meter readers and replaced many faulty customer meters; which resulted in a large increase in the billed amount. Moreover, following the successful reduction of NRW ratios at Kisumu and Nakuru WSPs through targeting large customers for servicing and replacing faulty meters, Eldoret WSP, which also has many large customers, has been targeting the large customers in their collective efforts to improve the

accuracy of customer meters and to reduce illegal connections. Meanwhile, some of the pilot WSPs requested the experts to support them in evaluating the effectiveness of their recent activities on customer meters by repeating the analysis of meter reading and billing data. Since analysis of these data over 12 months was too time consuming and technically difficult for most WSPs, the Project team developed a new method of comparing the data for only two months (before and after the improvement) to more easily evaluate the effectiveness of their activities.

8. Measures against physical water losses

One or more pilot areas were selected for leak reduction activities in each WSP. Minimum night flow measurements and step tests were conducted in those areas to estimate the level of total leakage and identify subsections having large leakage within the areas. Leak detection and repair work were then conducted in the subsections that had significant leakage. However, some challenges emerged. For example, the leakage volume in some pilot areas was once successfully reduced through the activities but later increased over time. Accurate estimation of the leakage volume through minimum night flow measurements was also found difficult in intermittent water supply areas. Relevant data was collected and analyzed by each WSP to improve the methods of leak detection.

2.5 WASPA and WSPs in the country（Output 5）

In Output 5, the Project activities aims at sharing lessons learned in NRW reduction activities at pilot WSPs and other donors or other WSPs, so that NRW reduction activities can be expanded all over Kenya. This will be done through WASPA's network of more than 60 member WSPs including the pilot WSPs. Through WASPA's bi-monthly meetings and thematic workshops for targeted NRW practitioners, the Project will share successful cases and lessons learned with other WSPs.

3. Results of the Project Approach

The status of activities and achievements from January 2019 to March 2020 is presented in this section.

3.1 Strengthening the NRW Unit function（Output 1）

To gain experience in NRW sensitization at the national level, the NRW Unit conducted the following activities.

1. NRW sensitization

A. Sensitization of county governments

Enactment of the Water Act in 2016 made county governments responsible for the water services. It therefore became important for counties to understand the importance of reducing NRW. To promote understanding of NRW, the NRW Unit planned sensitization workshops targeting county government officials and WSP managers in several locations. Two workshops have been held so far in Nakuru and Laikipia Counties targeting these and surrounding counties.

B. Sensitization of the general public

For sensitization of the general public, the NRW Unit exhibited posters on NRW related issues during the World Water Day and other public events, and published the Annual NRW Report. Through such activities, sensitization activities by the Unit will be regularized. During the World Water Day event on 22nd March 2019, the Unit co-exhibited NRW sensitization materials with Kakamega County Urban Water and Sanitation Company (KACWASCO). Organizing NRW sensitization activities together with a WSP in the area of the event could increase the awareness of the WSP of the importance of sensitization. At the World Water Day, KACWASCO NRW team voluntarily modeled demonstration piped water system and leakages. Using posters on NRW, the Unit and KACWASCO managed to actively educate the visitors on NRW issues.

KACWASCO officer explaining about NRW to visitors during the World Water Day event

C. Sensitization activities at WSPs (visits to water treatment facilities)

As part of the NRW sensitization activities, WSPs invited primary school children to their Water Treatment Plants (WTP) to learn about the water treatment process and the costs of water production. Embu WSP has been conducting this activity regularly. The aim of the event is to teach pupils about the importance of water

conservation and illegal water use, and encourage them to discuss what they have learnt from the visits with their parents and families. At WASPA's bi-monthly meeting in March 2019, Embu WSP made a presentation on their activities and invited representatives from four WSPs who expressed interest to the next schools' visits to observe the activities. As a result, Murang'a WSP invited primary schools to their WTP in Feb. 2020. Murang'a had suffered political interference whereby the county government unlawfully stopped the WSP's operations in April 2019. The governor of Murang'a had called for withholding of water bill payments by the residents, causing temporary financial damage to the WSP. It is likely that this experience convinced the Managing Director of Murang'a of the importance of sensitization activities as he was the one who initiated the activity.

When children from public schools are to be engaged in out-of-school activities, the school is required to get permission from the county government. To support the WSPs in easing the approval process, the NRW Unit sent letters to the county governments requesting their approvals. Nyahururu WSP conducted their own sensitization activities by visiting schools to educate the children about NRW. These activities imply that WSPs are gradually recognizing the importance of educating children.

2. Production of Annual NRW Management Report

The NRW Unit has already issued their first (2017/2018) Annual NRW Management Report with the aim of informing water services stakeholders and the general public about NRW-related issues. One thousand copies of the report were printed in June 2019. The report was officially launched by the Cabinet Secretary in August 2019 and distributed during public events of the Ministry. It can also be downloaded from the Ministry's website.

The draft report for the second issue was completed in April 2020 and was in the editing process as of May 2020.

The first Annual NRW Management Report

3.2 Revision of NRW Management Standards (Output 2)

In June 2018, WASREB formed an Editorial Committee to revise the current NRW Management Standards. The Committee members are representatives from WASREB, MWS&I NRW Unit, KEWI, WASPA, Council of Governors, and the JICA expert team. As of March 2020, 13 committee meetings have been held. To understand the current usage of the Standards, WASREB conducted a water audit study (in 2018 and 2019) and the Committee conducted a survey (from February to April, 2019) on usage of the Standards by WSPs.

The water audit study was financed by the Netherlands and targeted nine WSPs. The results of the audit indicated that most WSPs knew about the Standards but did not fully use them because the concept and activities of NRW reduction differs in each WSP hence they do not have much need for using the Standards. In addition, 66 WSPs participated in the survey on usage of the Standards whose summary from 44 responses are as follows:

- 80% of WSPs knew of the existence of the Standards, and the content is easy to understand.
- 54% of WSPs refer to the Standards as the need arises.

Nevertheless, the responses suggested that WSPs were too busy with their daily work and many do not consider NRW reduction activities as important. It was apparent that WSPs were not fully using the current Standards. Some responded thus: "There is no budget or equipment for conducting NRW reduction activities", "We do not know what to do with NRW reduction", or "We cannot say the Standard is appropriate because we do not have experience in conducting NRW reduction activities".

Through the survey, it was revealed that there were staff in many WSPs who had participated in seminars or training to gain some knowledge on NRW reduction. There seemed to be many WSPs with such staff but the staff did not have successful experience in NRW reduction activities. WSPs that are already implementing NRW reduction activities requested that the content of the revised standard include information on how to effectively reduce commercial losses, how to reduce NRW with simple equipment and methods instead of relying on expensive equipment, and templates for specific NRW reduction plans.

The current Standards consists of four volumes: Guidelines, Manuals, Handbook, and Case Studies. Each volume targets: the staff in charge of NRW management in Water Service Boards (WSBs), the NRW officers in WSPs, and the field technicians, respectively. At the time

the current Standards were formulated, the term "Non-Revenue Water" was not fully understood among WSPs. Thus, the emphasis of the Standards was to enhance the understanding of its contents in order to promote the Standards smoothly and widely. As time passed, the importance of NRW reduction was politically recognized widely and the average countrywide NRW ratio was announced as about 50% of the total water supply. This led to attention being focused on NRW reduction activities in the water sector. Further, the enactment of the Water Act 2016 brought the abolishment of WSBs and the county governments became responsible for WSPs. The need for revision of the current Standards therefore emerged. Based on this background, the Editorial Committee formulated its policies for the revision of the Standards as follows:

1. Since many WSPs already had some knowledge and experience of NRW reduction, the information included in the "Case Studies" volume of the Standards may not be in high demand. Information about successful cases or approaches on specific topics may be shared better more timely through the Annual NRW Report, WASREB's Impact Reports, or other means. The Committee therefore decided not to incorporate "Case Studies" in the revised Standards.
2. Due to abolition of the WSBs, there would be no need for compiling the Guideline and the Manual separately, hence these two volumes could be merged into one volume. The merged volume would be called "Guidelines" following the term used in the Water Act 2016.
3. The Committee decided that the new NRW Management Standards would consist of two volumes "Guidelines" and "Handbook". The Guidelines was earmarked for use by the managers and staff in charge of NRW reduction activities in WSPs, while the Handbook was earmarked for use by field technicians. The contents of each volume was to meet the needs of the level of the respective target group.

The following are the key points of the new Standards. WASREB is considering adopting the following contents from the Standards as licensing conditions for WSPs:

- Use of the planning and reviewing template for preparing annual NRW reduction plans.
- Management of customer meters, and conducting meter reading and billing data analysis to identify problems and taking remedial measures against them as the commercial loss reduction approach.
- Comprehensive data management using GIS and/or Kobo Toolbox for mapping of pipe network (including recording of locations, pipeline/facility materials, maintenance records, customer care records, etc.).

The Editorial Committee plans to complete the first draft of the NRW Management Standards by May 2020 and conduct stakeholder meetings, including compiling their feedback, and finalize the Standards by the end of 2020. Dissemination of the new Standards is planned for early 2021. The main challenge is how to effectively disseminate and ensure WSPs understand the contents of the Standards. To tackle the challenge, the Project is proposing to establish a working group to undertake the dissemination and to promote use of the Standards by WSPs.

3.3 Capacity building through formulation and implementation of NRW training courses (Output 3)

Through the baseline survey, the key challenge that the NRW short course did not respond to the needs of WSPs because it focussed on only lectures was identified. Then KEWI reviewed the training course, which was prepared in the previous project, and formulated a new course which includes practical on-site trainings conducted in collaboration with the leading WSPs of Embu and Meru. The new course is called "NRW reduction practical course" (hereafter called "Practical Training"). The course consists of a 5-day lecture session and 6-day OJT session. For this course, KEWI developed the entire course contents and produced the corresponding textbooks.

The OJT sessions have been conducted at Embu WSP to-date, using their facilities due to lack of proper facilities for conducting OJT sessions at KEWI campus. KEWI conducted the first Practical Training in June 2017 and proceeded to conduct six more up to June 2019. At the end of each training course, KEWI evaluated the course and incorporated points from the feedback into the next training materials and teachings. KEWI intended to come up with a training course that suits the requirement of the WSP trainees following the Plan-Do-Check-Adjust (PDCA) cycle (Figure 2).

The Project component for supporting Output 3 activities of KEWI completed in phase 2. Through the activities, the following outcomes were achieved:

- In the process of formulating the Practical Training program, especially OJT with the leading WSPs, the lecturers gained knowledge of the on-the-ground work of WSPs and incorporated their knowledge into the lectures.
- In the process of reviewing and developing the contents of the Practical Training, the subjects needed by WSPs

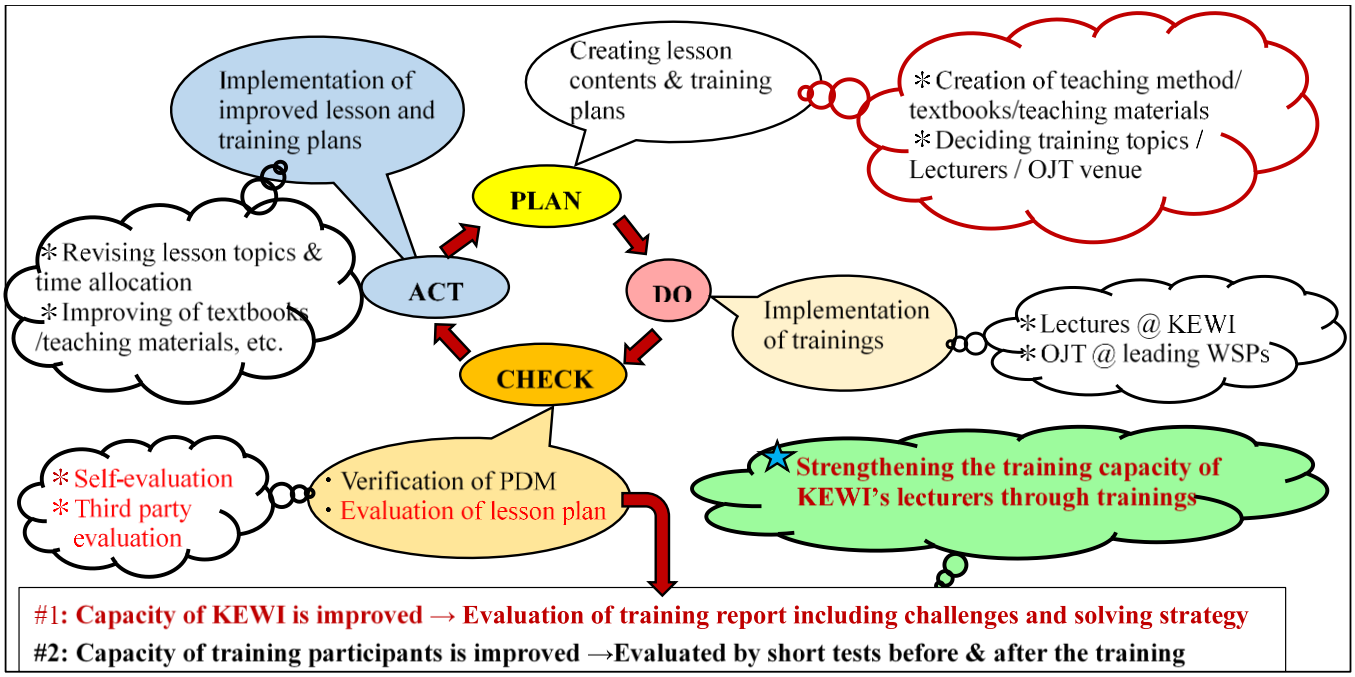


Figure 1: Strengthening capacity of KEWI using PCDA cycle

for NRW reduction activities were compiled thus: lecture textbooks for 20 subjects and 11 for OJT.

In the previous project, no textbooks were used during the training and trainees had to take notes from the lecturers' presentations. In the Practical Training, the trainees were ~~I~~provided with the textbooks to carry home, and hence they could use the books in their NRW reduction activities.

KEWI formed a NRW Unit of 10 members- 5 lecturers and 5 assistant lecturers. Some of the members are also lecturers of the KEWI's long-term courses. Improvements made from this course can be incorporated into the similar subjects of the long-term course.

・By applying the PDCA cycle introduced in the Project, it is expected that KEWI will continue to improve the course contents and/or teaching methods by itself.

・Through the implementation of six Practical Training sessions, in total, 142 participants were trained, representing from 26 WSPs. The participants were from various ranks and sections of WSPs: NRW reduction technicians, plumbers, meter readers, and billing officers, etc. The levels of satisfaction with the training were high so that the number of WSPs that repeatedly sent other employees to the training were increasing.

・A few months after the Practical Training, KEWI visited several WSPs to evaluate how the knowledge gained by the trainees was being applied to their works and to share their findings with the management of WSPs. This very new and commendable approach that they introduced was taken first at Nyahururu WSP in August 2019. Then Nyahururu WSP positively evaluated this review as useful because the positive outcomes of participating employees could revitalize or change the mentality of the organization.

These efforts by KEWI have shown results to the extent that some WSPs requested KEWI to conduct "tailor-made training" for their staff in their premises including conducting practical using their water supply facilities. In such cases, KEWI normally holds consultations with each client WSP to formulate the special training according to the WSPs' needs. Then, it dispatches the lecturers and equipment to the WSPs to conduct the training. KEWI has conducted several tailor-made training courses at some WSPs.

To show the achievement of Output 3, KEWI conducted short tests for the trainees before and after the Practical Training. The Project's indicator requires that test marks after the training to be higher than the marks before the training. The results of all six training sessions confirmed that the marks in every training were higher, thereby achieving its objective.

Forthcoming challenges of KEWI

The Project's support for KEWI completed in phase 2. In Phase 3, KEWI by itself continues conducting Practical Training four times a year using textbooks and teaching materials developed by the Project. One of KEWI's

future key challenges is how to increase the number of training participants. One method is by formulating suitable training brochures and advertising through various media outlets. The new NRW Standards (currently under revision by Output 2) will include various technologies and skills used in Output 4. KEWI is expected to play an important role in effective dissemination of the technologies and skills incorporated in the new Standards to WSPs through establishing new training program.

3.4 Preparation of NRW reduction plans reflecting WSPs' existing conditions and their implementation (Output 4)

1. Preparation of NRW reduction plans & capacity assessment

In order for WSPs to improve their capacity for self-assessment (which is necessary for the preparation of NRW reduction plans), a checklist containing about 250 NRW-related check points has been integrated into an assessment template for the WSPs to aid them in conducting the capacity self-assessment.

As a result, all the pilot WSPs managed to update their medium-term NRW reduction plans and prepare their annual plans in 2019 based on the results from their comprehensive self-assessment. Figure 3 shows the results of capacity self-assessment of Nyahururu WSP in a single graph, which is part of the assessment template. As shown in the figure, the check points were divided into 4 large categories. Each large category is sub-divided into 3 or 4 subcategories, totaling 14 medium-sized categories. Lastly, each of the 14 medium-sized categories are further subdivided into 2 or 3 small sizes, totaling 33 aspects/small categories (the 33 bars in the upper half of the graph). Although it is not shown in this figure, around 250 relevant points need to be ticked to complete the graph (8 for each aspect on average). In the template, each check point is represented by a checkbox to click depending on whether the check point has already been achieved or not. By selectively ticking the checkboxes, the template automatically calculates scores and presents the results on the graph. Moreover, each WSP can set its target levels in 1 and 5 years for each aspect, and prioritize the aspects to improve faster. Showing these assessment results, targets and priorities on the same graph makes the planning process easier. This template is still being improved so that the preparation of NRW reduction plans based on the assessment and the sharing of the plans among staff of each WSP becomes more efficient.

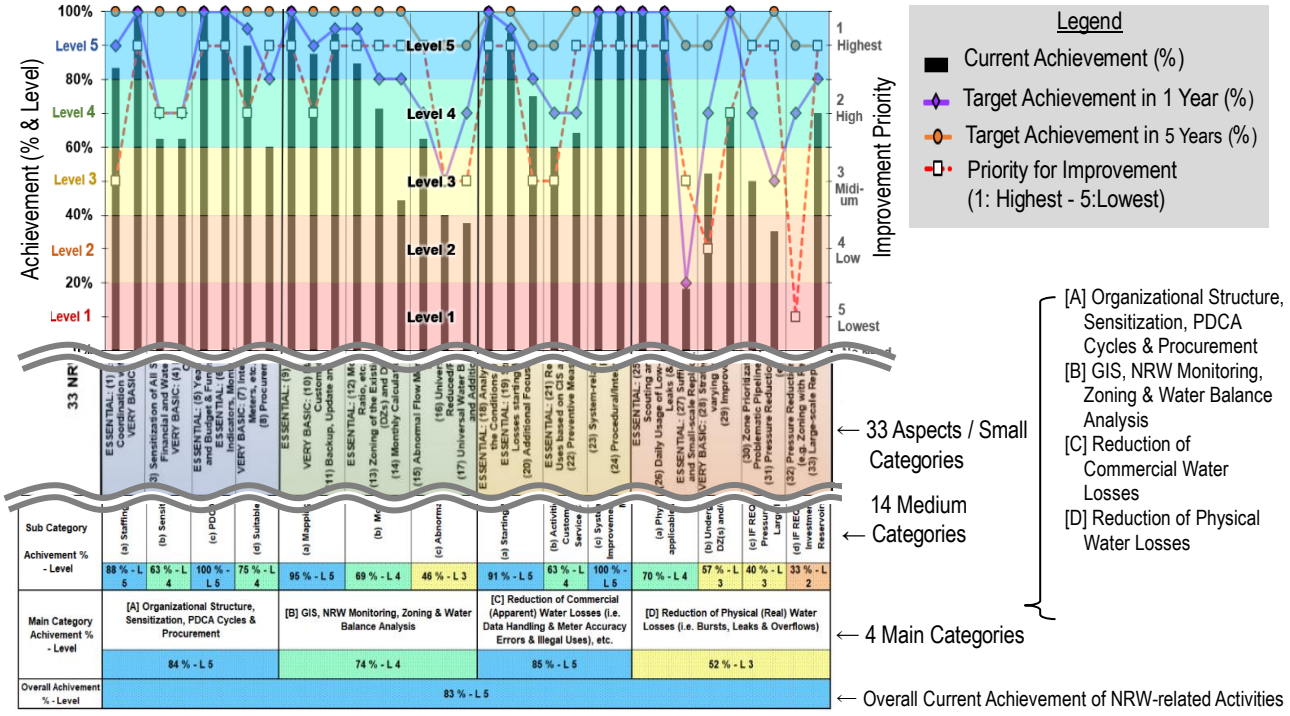


Figure 3. Results of the capacity self-assessment, and targets & priority for improvement set at Nyahururu WSP

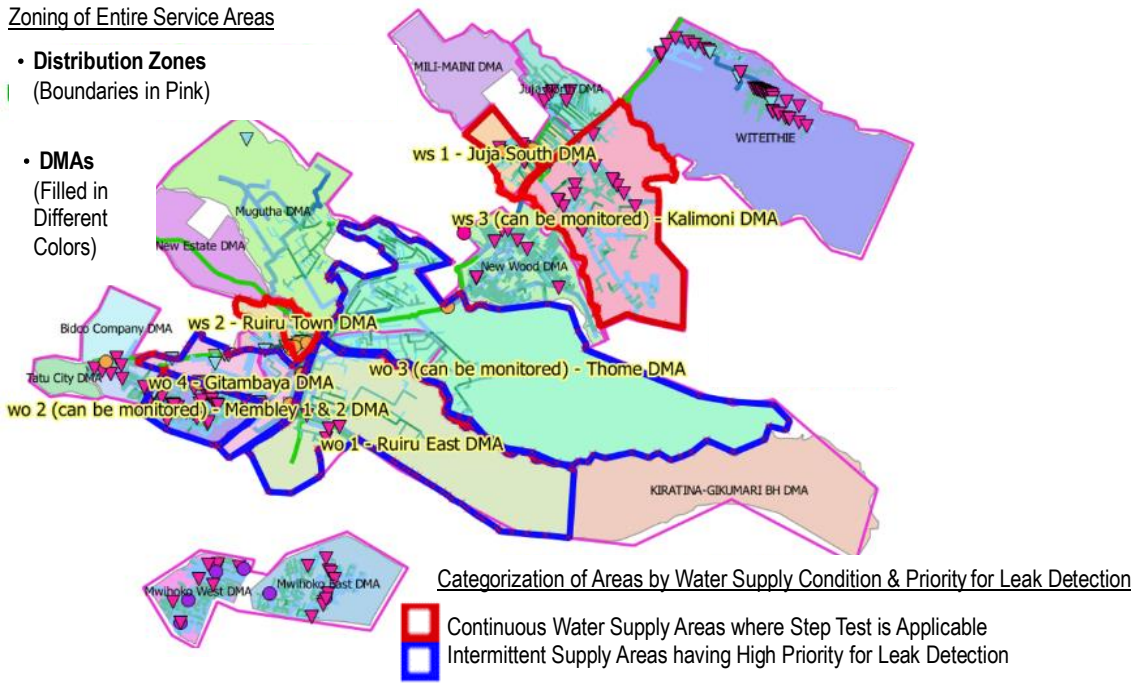


Figure 4. Map of entire service area and leak detection methods & prioritized for each zone at Ruiru-Juja WSP based on their zoning plan

2. GIS preparation & zoning of distribution systems

The existence of a mixture of continuous and intermittent supply areas in many pilot WSPs makes it more difficult for the WSPs to envision how to expand their leak detection activities over their entire service areas. As an example, Figure 4 shows Ruiru-Juja WSP's plan to expand their leak detection activities over their service area where continuous and intermittent water supply are mixed. This expansion plan is mapped on their zonal GIS map (for separating distribution zones and DMAs). This figure shows the continuous water supply areas where step tests can be used for leak detection (in red) and the selected intermittent water supply areas which have high priority for leak detection (in blue). WSPs can select their pilot areas for leak reduction strategically and improve effectiveness and sustainability of leak detection activities by considering their current and future water supply conditions based on their zoning plans.

3. Monitoring the progress of NRW reduction

The graph in Figure 5 shows Nyahururu WSP's monthly data (3 types of raw data and 4 indicators calculated from the raw data) for 3 years, indicating the seasonal fluctuations of NRW ratio and the effects of NRW reduction activities. In this example, the NRW ratio (Red △) has decreased by around 10% over the last two years while showing its seasonal fluctuations repeated every few months. Regarding the seasonal fluctuations in dry seasons, the total water supply (Orange ○) and total billed consumption (Purple ○) usually increase at a similar rate in each dry season because the shallow wells used by small customers (as alternative water sources) dry up. Therefore, the amount of NRW (Red ○) (=supplied water - billed consumption) does not change much in the dry season. Consequently, the NRW ratio (amount of NRW / supplied water * 100) seems to decrease for a few months in every dry season.

The reason why the average tariff for water supply (Blue ◇) (=billing (Green □)/billed consumption) decreases in the dry seasons is that the piped-water consumption among small customers (those paying relatively low water charge per unit consumption due to the incremental block tariff) increases in dry seasons due to their dried-up wells. At WSPs in Kenya, water shortage and intermittent water supply conditions often affect the total amount of water supply while the seasonal fluctuations of water demand affect the total billed consumption significantly. These values fluctuate repeatedly due to seasonal changes of temperature and precipitation. The phenomenon shown in this example, that NRW ratio (Red

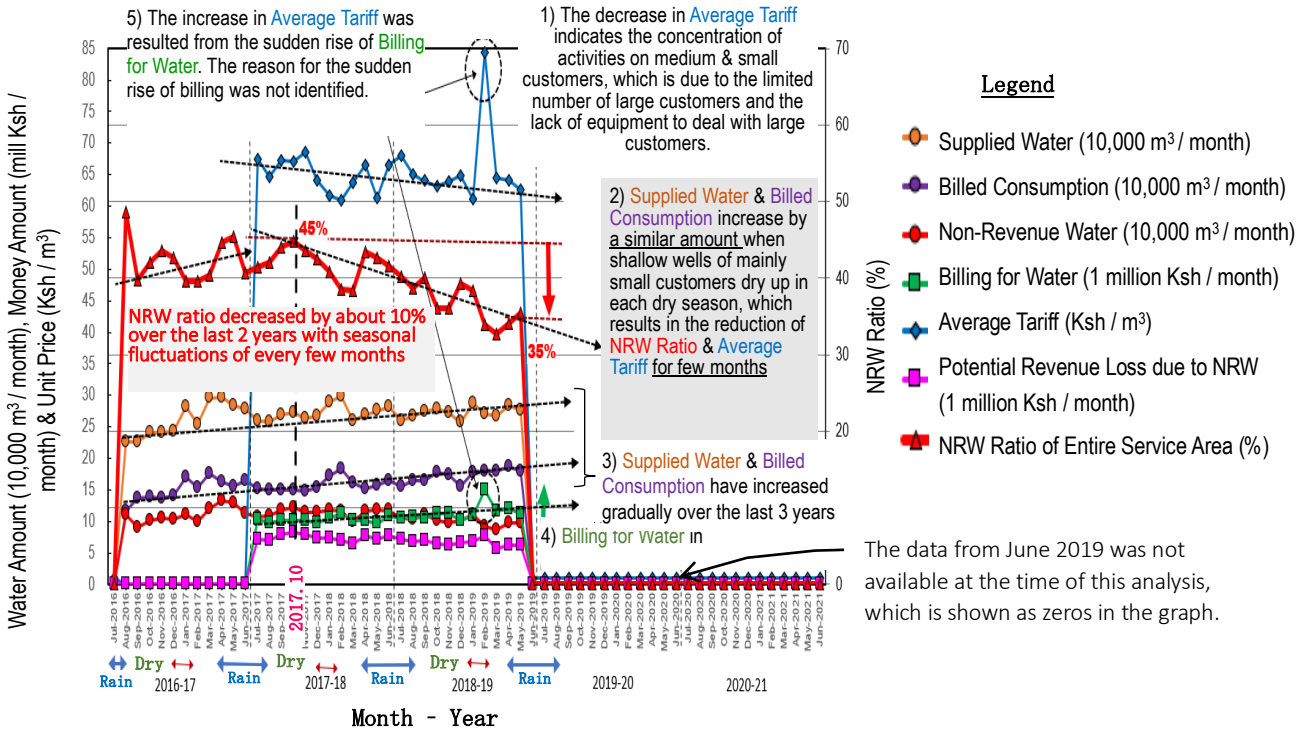


Figure 5. Multi-year analysis of monthly data showing seasonal NRW fluctuations and effects of activities at Nyahururu WSP

△) often goes up and down every few months, is found to be common in Kenya.

As shown in Figure 5, the variation in the monthly water supply volume (Orange ○) is a useful indicator to estimate the progress of physical water loss reduction. The total billed consumption (Purple ○) and the total amount of billing (Green □) are effective indicators for understanding the progress in reducing commercial losses caused by meter errors, water theft, etc. Moreover, the average tariff (Blue ◇) usually increases as the billing to large customers improves. It is a good indicator of how well large customers have been targeted in the implementation of commercial loss reduction activities. The amount and ratio of NRW for the entire service area (Red ○ & Red △) and the potential revenue loss due to NRW (Pink □) are useful indicators for quantitative evaluation of the overall effect of NRW reduction activities. This analysis using a line graph is much easier and often more effective than formulating a complicated annual water balance table of the entire service area. By updating this analysis, the seasonal fluctuations and the effects of activities implemented against commercial and physical water losses can be simultaneously monitored each month, and thus more effective activities can be prioritized in the following months. This is the approach being used by the pilot WSPs. WASREB, the regulator, has also recognized the effectiveness of the approach in monitoring the progress of NRW reduction at each WSP and is planning to promote it widely.

4. Reduction of Commercial Water Losses

Table 2 shows the results of analyzing Nakuru WSP's monthly meter reading and billing data for two months only (Oct. 2017 and May 2019), which shows the differences between before and after reduction of meter accuracy errors and improvement of meter reading and billing practices. This analysis comparing only two months is an easier alternative to the previous analysis which was using meter reading and billing data for an entire year. This example shows that the reducing the billings of large customers based on estimated consumption (see columns [4] and [5] in the table) has significantly increased the total billed consumption and total billing (by around 107,000 m³/month (17%) as shown below [2]).

3.5 Sharing Project achievements and lessons (Output 5)

Through WASPA's by-monthly meetings, the Project is sharing its outputs and lessons learnt. Embu WSP gave

Table 2. Analysis on the reduced frequency of estimating billed consumption by customer size at Nakuru WSP

Customer Category by Average Billed Consumption	Year - Month	Number of Connection [1] Num	Distri-bution %	Billed Consumption [2] Total Volume (m^3/month)	Distri-bution %	[3](=[2]/[1]) Average (m^3/month/customer)	Customers whose Consumption is Estimated [4] Num	Distri-bution %	[5] (=[4]/[1]) Frequ-ency %	Number of Customers for Each Type of the Consumption Estimation: Increase from no consumption 0↑X	Increase from other than no consumption +X	Change to no consumption X↓0	Decrease to other than no consumption -X
C1: > 300 m3/month	2017 - October	130	0.3%	115,732	18.1%	890.2	17	0.2%	13.1%	15	1	0	1
C2: 101-300 m3/month		465	1.2%	74,839	11.7%	160.9	64	0.8%	13.8%	36	18	0	10
C3: 51-100 m3/month		1,077	2.7%	73,597	11.5%	68.3	155	1.9%	14.4%	110	27	0	18
C4: 21-50 m3/month		4,664	11.6%	144,864	22.6%	31.1	891	10.9%	19.1%				
C5: 7-20 m3/month		15,330	38.0%	181,004	28.3%	11.8	4,800	58.6%	31.3%				
C6: 0-6 m3/month		18,630	46.2%	49,882	7.8%	2.7	2,267	27.7%	12.2%	1989			
Total		40,296	100.0%	639,919	100.0%	15.9	8,194	100.0%	20.3%	7,464	437	9	284
C1: > 300 m3/month	2019 - May	114	0.3%	130,787	18.9%	1,147.3	4	0.1%	3.5%	2	0	0	2
C2: 101-300 m3/month		601	1.4%	94,577	13.7%	157.4	43	0.6%	7.2%	23	11	0	9
C3: 51-100 m3/month		1,375	3.3%	93,946	13.6%	68.3	127	[illegible]	9.2%	95	14	0	18
C4: 21-50 m3/month		5,769	13.7%	177,675	25.7%	30.8	[illegible]	11.1%	14.0%	726	44	0	35
C5: 7-20 m3/month		16,971	40.4%	199,200	28.8%	11.7	3,959	54.7%	23.3%	3702	192	0	65
C6: 0-6 m3/month		19,437	46.2%	50,480	7.3%	2.6	2,058	28.4%	10.6%	1767	163	14	114
Total		44,267	100.0%	746,666	100.0%	16.9	6,996	100.0%	15.8%	6,315	424	14	243

Effective focus on large & medium customers (reduction of about 10% to 5%)

Increase of customers by around 4,000 (10%)

Large increase of billed consumption by around 107,000 m^3/month (17%)

Reduction of the number of customers whose consumption is estimated by around 1,200

Reduction of the estimated consumption for billing by 4.5% on average

Mainly by replacing the faulty meters which are completely stalled.

a presentation regarding a student visit to their water treatment plant at WASPA's meeting and grabbed the attention of some WSPs. In August 2019, the thematic workshop on "Unauthorized Water Use" was organized with the aim of getting the WSPs practitioners to share the successful cases of prevention of water theft and issues around water theft. This attracted more than 80 participants in a hall with a capacity of 60, showing the great interest generated by this theme. Some of the key issues were: a lack of unified regulations and penalties by central and county governments, and lack of stringent penalties. The participants agreed that there was a need to strengthen the regulations and improve the ethics of WSP employees.

4. Lessons and Innovations resulting from Project Implementation

1. Sensitization activities led by WSP management

The NRW Unit has been promoting sensitization activities for primary school children. Even though the number of activities is small, some WSPs started following Embu WSP's steps. It is common that primary school children visit water facilities in Japan. However, this kind of activity did not exist in Kenya before. Even for the teachers who came to the visits, it was their first time to visit a WTP. This is a low cost activity for WSPs; the only cost required may be the transport (bus) cost. However, without the support of WSP management including the managing director, the activity will not happen. It is important that top management of WSPs understands the effectiveness and need for this kind of sensitization activities. Two WSPs (Murang'a and Nyahururu) conducted sensitization of primary school children where their managing directors initiated their activities. For this kind of activity to continue expanding, it is important to provide opportunities for WSP managers to observe and experience the sensitization activities themselves.

Murang'a WSP workers explaining to pupils visiting the Water Treatment Plant

2. Importance of selecting target areas for NRW reduction activities

In order for pilot WSPs to reduce NRW quickly and effectively, it is quite important to consider their entire

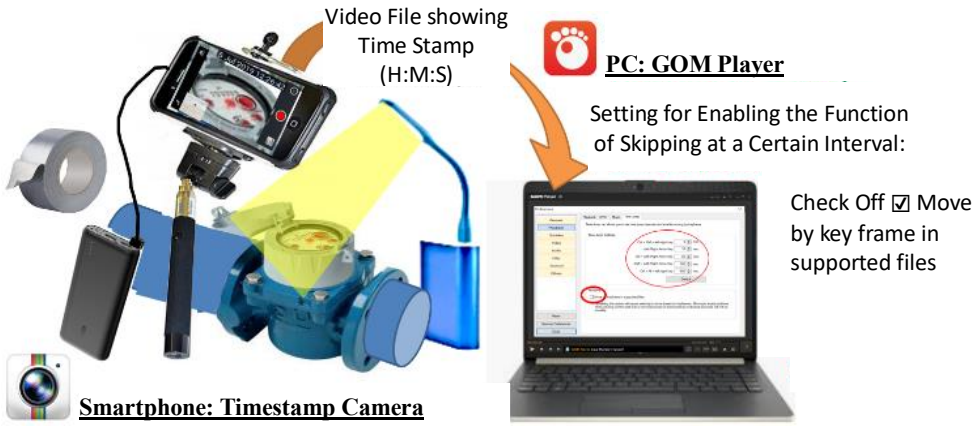


Figure 6. Measurement of the hourly fluctuation of water distribution with low-cost smartphone & free software (Trial)

service area from the early stage of NRW reduction activities. Basic activities like reduction of the number of customers not registered or not metered, reduction of visible leaks, replacement of faulty customer meters (especially for large customers); and in-house standardization of optimum piping, joints, etc., for new installation and their application on site) should be quickly expanded over their entire service area. By implementing these basic activities in the Project, five (5) pilot WSPs managed to reduce their NRW ratios by around 10% to 15%. Meanwhile, setting up hydraulically-isolated pilot areas (e.g. DMAs) specifically to try out leak reduction activities such as leak detection and pressure control is considered to be effective. These activities can be expanded to other areas after carefully confirming the effectiveness in the pilot areas.

3. Encouraging organization-wide NRW reduction activities

In order to ensure the full involvement of the commercial department in NRW reduction activities to reduce commercial losses, the meter reading and billing data of all the customers over 1 to 2 years was analyzed, and the problems found from the analysis (e.g. many faulty meters, and frequent & continuous under-estimation of billing even for large customers) were shared with managers and staff of each WSP. This kind of activity made a strong impact on all the pilot WSPs. Since then, holding joint monthly meetings between technical and commercial staff for NRW reduction became more common in WSPs. Moreover, four WSPs have successfully strengthened their organizational setups for NRW reduction while Ruiru-Juja and Kilifi-Mariakani are in the process of strengthening.

4. Sustainable and expansive utilization of Information and Communication Technology; ICT

Application of Information and Communication Technology (ICT) including smartphone-based data collection and mapping has been tried out to find more efficient ways to carry out NRW reduction activities. In the early stage of the Project, Open Data Kit (ODK) free software was used to create an interactive electronic form to guide the activities related to customer meters to collect relevant data. However, the development and use of a common integrated e-form (intended to be shared among WSPs) faced difficulties due to differences in organizational structures and priority activities of WSPs. Therefore, the Project switched to another free software called Kobo Toolbox/Collect[2)] which is easier for WSPs to use. With this software, WSPs can now set up their own cloud space for data sharing, create their own e-form for each activity, and map the results automatically. This change has made data collection using smartphones more sustainable and expandable.

5. Consideration of suitable solutions for each WSP

Since equipment owned by each pilot WSP differs significantly from the others, the Project has been

[2)]; Field data collection and management smartphone application.

providing training not only on the operation of the leak survey equipment that is being gradually procured by MWS&I but also on the equipment procured by each WSP and/or WSB. The Project had to adjust to the situation and conducted flexible OJT with the equipment available at each WSP. The Project also tried to use low-cost industrial clamp-on ultrasonic flow meters (UFM), which can be easily procured by WSPs, as a potentially sustainable alternative to conventional portable UFM. However, setting up and ensuring the accuracy of the industrial equipment was problematic. As another alternative, the Project suggested that some WSPs use the video recording functions of smartphones for logging of flow fluctuations as a trial. Figure 6 shows the sequence of filming the counter of a mechanical bulk meter with a smartphone and reading the counter at intervals later from the video to figure out the changes in flowrate. This method can make minimum night flow measurement and step tests easier without using a portable UFM and may help many WSPs in their leak detection. The Project has been experimenting with technologies and approaches together with the pilot WSPs. Continuous trials and exchange of information with the stakeholders are important to tackle the challenges without causing a large financial burden on WSPs especially now that the use of OA equipment and available free software programs continue to increase.

(Project Implementation Period: from Oct. 2016 to Sept. 2021)

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