Waterlines, 41:2, 96–106
<http://doi.org/10.3362/1756-3488.21-00015>

Sustainable management of water utility in Samoa through services improvement with Okinawa Water Bureaus

Ryuji Ogata, Shigeyuki Matsumoto, Motomu Takara, Leiataua Semi Lesa, and Keisuke Ujike

Abstract: *This study examines how Samoa improved the capacity of Samoa Water Authority (SWA) by implementing integrated cooperation with water utilities in Okinawa Prefecture, and hardware and software development to reduce the high non-revenue water (NRW) ratio and improve water supply quality and inadequate water pressure. Standard operation procedures were formulated to enhance the capacity of SWA. The cooperation method adopted continuous on-the-job training with a bottom-up approach. Consequently, the NRW ratio was reduced from 68 per cent to 36 per cent and water supply with proper pressure was achieved in the targeted area. The quality of the tap water, in which many coliform bacteria were detected before the cooperation, achieved 100 per cent compliance with standards. The cooperation evidenced that improving water services can help users' understanding of tariff payments, although the water tariff increased for most consumers due to a shift from fixed to metered tariff.*

Keywords: service improvement, water utility, non-revenue water, water quality monitoring, willingness to pay

SAMOA IS AN ISLAND NATION comprising two main islands in the Pacific Ocean, namely, Upolu and Savai'i, with its capital in Apia (population of 40,000). In recent years, the Pacific Islands' inhabitants have been exposed to risks associated with climate change, such as concerns regarding the sustainability of Samoa's water supply (Fakhruddin et al., 2015). Specifically, a previous study reported that cyclones, which have become more frequent due to climate change, have a significant impact on water quality (Mosley et al., 2004). Furthermore, using water resources efficiently is a more serious issue in islands, where water resources are relatively scarce compared to inland areas (Keen, 2003). The Samoa Water Authority (SWA), which employs approximately 260 staff members and serves approximately 85 per cent of the population (about

Ryuji Ogata (ogata.ryuji2@jica.go.jp) Senior Advisor for WASH, JICA Headquarters, Japan; Shigeyuki Matsumoto (matsumoto.shigeyuki@jica.go.jp), Deputy Director General, Global Environment Department, JICA Headquarters, Japan; Motomu Takara (qqxf2khd15926535@gmail.com), Freelance Consultant; Leiataua Semi Lesa (Semi.Lesa@swa.gov.ws), Urban Non-revenue Water Engineer, Samoa; Keisuke Ujike (ujike.keisuke@jica.go.jp) Country Officer (Samoa), Global Environment Department, JICA Headquarters, Japan

www.practicalactionpublishing.com, ISSN: 0262-8104/1756-3488

170,000 in 2020), supplies water in Samoa. In 2017, 97 per cent of the Samoan population had access to improved water, while only 59 per cent of the population had access to safely managed water (WHO and UNICEF, 2021). According to the results of Latū et al. (2012), all the samples from springs used as drinking water sources in Upolu were found to have faecal contamination. These results indicate that there is plenty of room for improvement in Samoa's water supply services.

Samoa has a large outflow of human resources, with many people migrating to New Zealand and Australia. The SWA staff does not remain with the organization for a long period. In addition, no standard operation procedures (SOPs) were in place for the implementation of operations, and self-initiated responses were widespread. Although the SWA staff had a certain level of knowledge and technical skills in pipe construction and leak repair, their habit of skipping sequential execution of proper procedures had become a norm. This situation was the cause of the high non-revenue water (NRW) ratio and poor water quality. The high NRW ratio due to leaks was one of the largest challenges for water supply in Apia City. The NRW ratio in Alaoa (with a population of 18,000), which is the largest water district in Apia City, was 68 per cent in 2014. In addition, some water districts did not have water treatment plants (WTPs) and supplied raw, turbid water. Even water districts with WTPs were not operated properly, especially during high turbidity seasons after rainfall, and they did not meet the SWA water quality standards. Owing to the low level of service, customers were not satisfied with the water services. In addition, fixed tariffs, low tariff collection rates, and high NRW ratios caused a vicious circle in the SWA's financial situation. However, this vicious circle seems to turn around after better customer service is established, as many studies revealed that customers expressed a 'willingness to pay' for better services (e.g. Akram et al., 2011; Asim and Lohano, 2015; Tussupova et al., 2015).

Methodology

With low quality of service, such as turbid tap water, it is difficult to increase revenue through water tariffs. Therefore, the SWA's integrated cooperation adopted a bottom-up approach. First, they improved the service; then, by delivering results to the customers, they built a relationship of trust with them, which increased the customers' willingness to pay. They shifted from a fixed tariff system to a metered system; and they improved the management of SWA along with the reduction of NRW. Capacity development alone was not sufficient to improve the water supply situation in Apia City; therefore, the water supply infrastructure was improved through a grant aid project. The Japan International Cooperation Agency (JICA) worked with local governments in Okinawa Prefecture to implement a package of cooperation that combines several schemes: short-term training courses, technical cooperation projects, and grant aid projects, which included hardware and software support. Figure 1 shows the location supported by the grant aid project and technical cooperation in Apia City.

Table 1 summarizes the contents of hardware and software inputs through Japanese grant aid and technical cooperation projects, and Figure 2 shows the

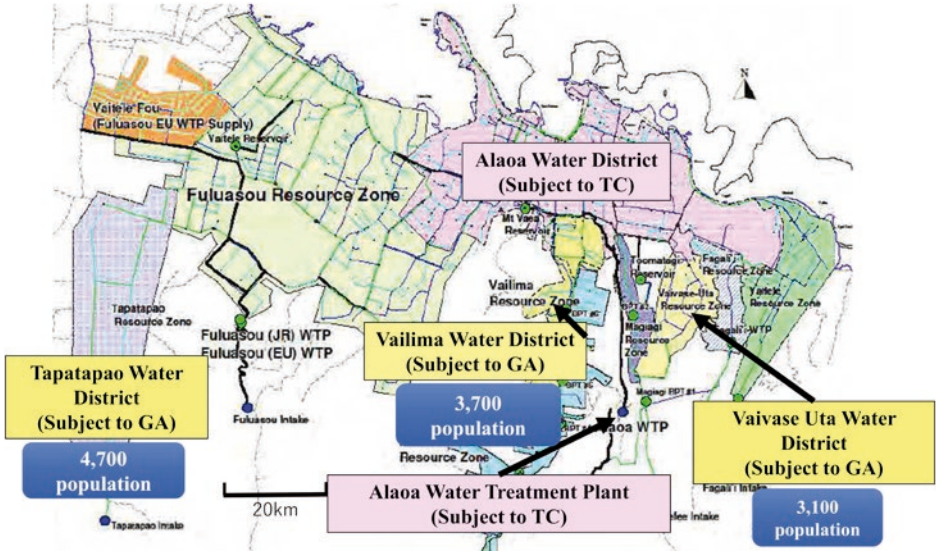

Figure 1 Location of assistance through different schemes in Apia City
Note: GA: grant aid; TC: technical cooperation

Table 1 Summary of inputs for improvement of water supply in Apia City (GA and TC)

Grant aid project (hardware support and preliminary operation and maintenance training)	JPY 1,844 m (US$16.9 m)[1]
Tapatapao WD: Rehabilitation of 1 intake facility, raw water pipe (1,453 m), 1 WTP (1,810 m^3/d), 1 clear water reservoir, 3 pressure breaking tanks, distribution pipe (14,870 m), 293 house connections with customer meters	
Vailima WD: Rehabilitation of 1 intake facility, raw water pipe (1,057 m), 1 WTP (1,430 m^3/d), 1 clear water reservoir, distribution pipe (11,076 m), 547 house connections with customer meters	
Vaivase Uta WD: 1 pumping station, transmission pipe (1,244 m), 1 service reservoir (600 m^3), 1 pressure breaking tank, distribution pipe (10,593 m), 440 house connections with customer meters	
Technical Cooperation Project (Alaoa WD and Alaoa WTP)	JPY 265 m (US$2.4 m)[1]
Japanese experts: Chief advisor, project coordinator, NRW management, pipeline works and repair, water quality management, asset management (GIS) 166.4 PM	
Equipment provision: Metal pipe locators, electro-magnetic flow meters, ultrasonic flow meters, pressure reducing valves, leak detectors, listening sticks, portable turbidimeters	
Local expenses in Samoa: Fuel, local personnel, local transport cost	

Note: [1] Calculated by the rate of US$1 = JPY 108.8 as of 2016
WD: water district; PM: person-months; GA: grant aid; TC: technical cooperation

timeline of series of support for water supply in Apia City. In the grant aid project by the Japanese government (US$16.9 m), intake facilities, two WTPs, a water transmission pumping station, pressure reduction facilities, and water distribution reservoirs were constructed. Further, water distribution and transmission

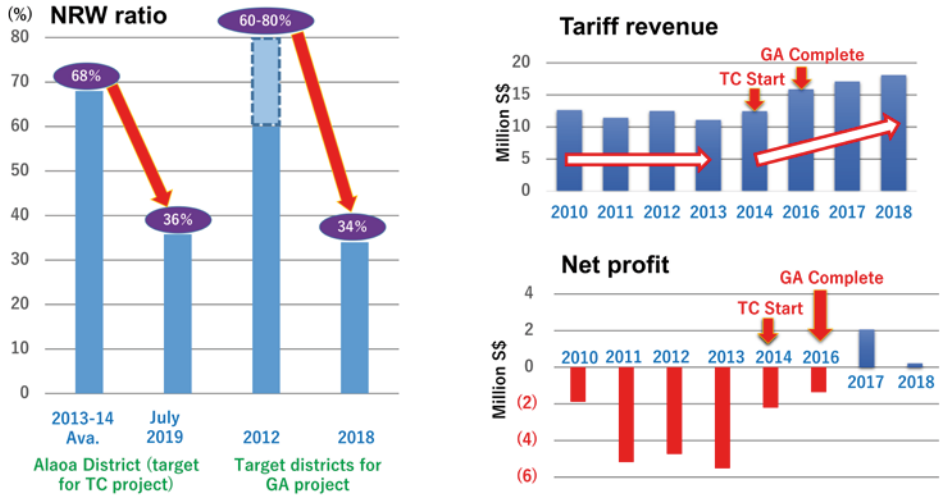

Figure 2 Timeline of the support for water supply improvement in Apia City

pipes were laid, and new water meters were installed in three water districts, Tapatapao, Vailima, and Vaivase Uta (JICA and Yachiyo Engineering, 2014). In addition to the infrastructure improvement, technical cooperation 'Capacity Enhancement Project for Samoa Water Authority in Cooperation with Okinawa' was conducted for Alaoa Water District from 2014 to 2019.

Alaoa had a WTP, water transmission, and distribution facilities; however, these facilities had operational problems. The cooperation between SWA and Okinawa, as a water-operators partnership (WOP), had a long history, even before the technical cooperation project began. Originally, there was a base of exchange through grassroots technical cooperation and issue-specific training from 2006 to 2013. Cooperation in the WOPs created a relationship of trust among water utilities, which increased the SWA's capacity to accept the project. JICA's funding resources made it possible to implement the grassroots technical cooperation on a larger scale over a long period. The project's long-term experts managed to remain close to the SWA staff, and day-to-day problems were jointly solved in the field. In addition, by inviting SWA staff to Japan's Okinawa Islands for training, they specifically understood the benchmarked waterworks business that they were targeting. Another feature of the WOP between Okinawa and SWA was that the Alaoa WTP used a slow sand filtration system, similar to some of those in Okinawa operating under the same tropical or subtropical climatic conditions. Based on the principle that purification of raw water uses biological membrane filters, Okinawa waterworks had the practical knowledge to operate the WTPs and, as such, appropriate technology was shared with SWA.

The technical cooperation project aimed to strengthen the capacity of SWA in five areas: enhancement of pipeline work capacity and leakage repair, improvement of water distribution management with appropriate pressure control, enhancement of capacity for leak detection, strengthening water quality monitoring, and improving the performance of the Alaoa WTP.

Specific activities of the technical cooperation project in the Alaoa Water District included the development of standard operation procedures (SOPs) as well as water distribution plans and water pressure management plans, implementation of internal training, and division of the distribution network into district-metered areas (DMAs). Visualized SOPs with pictures could be understood even by the staff with lower literacy levels in the field, and the project established a system to conduct operations that followed uniform procedures and quality control. The SWA WTP operators and plumbers in the field had operated and constructed the water supply systems on their own, without understanding the principles. Therefore, the project aimed to establish correct operation and installation methods through on-the-job training (OJT), based on the developed SOPs. The SWA did not conduct data collection in their daily work; therefore, they could not quantitatively understand the actual situation in the field. As such, there was a lack of clear focus for efficient handling of problems. To deal with these situations, the following measures were taken: 1) DMAs were established to measure the NRW ratio and were selected on a priority basis for efficient NRW countermeasures; 2) reference points were established to measure water pressure which was visualized on a map; 3) leakage was reduced and low water pressure was eliminated by maintaining the water pressure within an appropriate range; finally 4) water quality was improved. To monitor the NRW ratios, flow meters were installed at the appropriate points.

The training programmes comprised four-to-five week courses each, on pipeline works and leakage repair, water distribution management, leak detection, water quality monitoring, and WTP operation and maintenance, conducted by leaders of SWA with the support of Japanese experts. Achievement in the training programme was measured by paper tests and practical examinations.

Results and discussion

Following the training programme of classroom lectures and OJT, a technical examination was conducted to assess the skill and knowledge of the trainees in the latter period of the project. The results are shown in Table 2. A total of 55 SWA employees took the examination and 95 per cent passed. An internal technical examination for WTP operation and maintenance was not conducted as only two plant operators were assigned for Alaoa WTP. Instead, JICA experts confirmed that the plant operators carried out the operation and maintenance (O&M) work by following the SOP (JICA, 2019). In addition to the training programmes in Samoa, 19 SWA employees visited Japan for two weeks on average and were trained on NRW reduction, asset management, water quality control, and WTP operation, among others.

As integrated outcomes of SWA's capacity development and hardware improvements, supported by the grant aid project, improvement was observed in three categories of water supply services, as well as in the financial status (Table 3). The first category was water pressure control. The cooperation set the target between 100 and 400 kPa of water pressure at the tap; however, only 23.8 per cent of the

Table 2 The results of skill and knowledge examination after training programmes

Examination title	*Date*	*No. of examinees*	*No. passed*	*%* passed
Pipeline works and leakage repair				
PVC & saddle fitting technical test	August 2017	17	14	85
PVC fitting technical test	June 2018	16	16	100
Water distribution management				
Water pressure/water flow data logging test	October 2018	6	6	100
Leak detection				
Leak detection technical test	September 2017	4	4	100
Operation of leak detectors test	August 2018	8	8	100
Water quality monitoring				
Water quality skills test	September 2017	4	4	100
Total		55	52	95

Source: Adapted from JICA, 2019

Table 3 Summary of the key performance indicators in Apia City before and after integrated cooperation

	Before the projects (2012–2014)	*After the projects (2018–2019)*	*Remarks*
Water tariff system	Flat-rate	Metered-rate (97%)	
Revenue[2]	Total: S$11 m	Total: S$18 m	64% increase
Water supply time	8–12 hours	24 hours	
NRW ratio[1]	68%	36%	32% reduction
Water pressure[1] (100–400 kPa)	24%	84.8%	
Water quality	Contamination was observed	100% compliance with standard	
Bill collection	Low rate	100%	
No. of connections	16,230	29,222	80% increase

Notes: [1] Only Alaoa District
[2] S$1 (Samoan dollar) = US$0.38 (as of December 2018)

taps met the target in 2014. During the cooperation implementation period, SWA checked the water pressure in all target areas, replaced old pipes where the water pressure was too low, and installed pressure-reducing valves where the pressure was too high. Consequently, the water pressure improved to 84.8 per cent compliance in April 2019.

The second category was the quality of the supplied water. The water quality at the Alaoa WTP showed substantial improvement after June 2014, on examining the levels of *Escherichia coli* and total coliform stipulated by the Samoa National Drinking Water Standard. Before the technical cooperation project, the water-quality

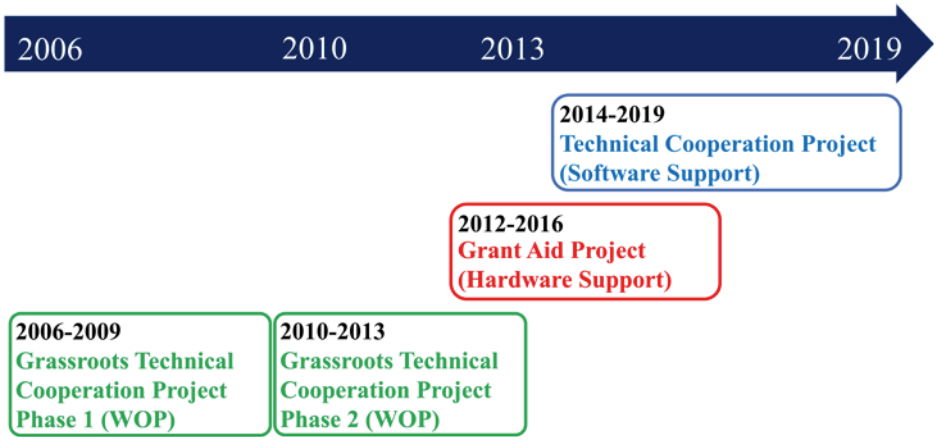

Figure 3 Reduction rate of NRW ratio on specific area, yearly tariff revenue, and net profit of SWA
Note: GA: grant aid; TC: technical cooperation

compliance rate at the Alaoa WTP was below 80 per cent. However, the water quality substantially improved as compliance with the drinking water quality standards at all seven WTPs in Apia reached 100 per cent after the cooperation, which was attributed to the improvement of O&M work at the Alaoa WTP.

The third category is the NRW ratio. The NRW ratio in the Alaoa water district was 68 per cent in 2014. Through SWA's cooperation activities and pipe replacement work, the NRW ratio was reduced to 36 per cent in 2019.

Figure 3 shows the NRW ratio in different areas of Apia City before and after the projects as well as the SWA's yearly tariff revenue and net profit. The NRW ratio in the Alaoa Water District, which is the target area for the technical cooperation project, and in the target districts for grant aid project significantly reduced from 68 per cent to 36 per cent and approximately 60–80 per cent to 34 per cent, respectively. With these activities, the NRW ratio in Apia City also reduced from 70 per cent in 2012 to 51 per cent in 2018. The SWA's management status also significantly improved because of the enhanced service level of the water supply in Samoa. The flat-rate tariff collection reduced after the customers' agreement regarding water supply, and 97 per cent of the customers accepted metered rated payments. The number of connections increased substantially from 16,230 in 2012 to 29,222 in 2018. The tariff collection rate also increased, reaching nearly 100 per cent. Owing to the integrated effects of the above-mentioned improvement of each key performance indicator, the SWA's revenue increased from S$11 m (US$4.18 m) in 2012 to S$18 m (US$6.84 m) in 2018. The SWA's income and expenditure balance in 2012 was –S$4.7 m (–US$1.79 m), but it became positive after 2017.

The reasons for such remarkable results from cooperation activities are explained as follows. First, 10 SOPs, including 4 SOPs for pipeline works and leakage repair, were developed, and internal training was regularly conducted; the SWA staff who engaged in pipeline work and leakage repair understood the appropriate pipe connection and leakage repair procedures through the OJT provided by the JICA

experts and SWA leaders. Subsequently, all pipeline work and leak repair procedures were carried out based on the SOPs. Thus, the leaks and water quality deterioration that occurred soon after the pipes were laid were greatly improved.

The SWA's NRW unit introduced a district-metered area (DMA) in areas with high amounts of predicted leakage and took effective measures to reduce NRW. SWA field staff acquired knowledge and skills to monitor water pressure, water volume, and NRW ratio, based on the formulated DMAs. Consequently, the NRW unit effectively conducted NRW reduction activities, prioritizing and selecting effective measures such as pipeline replacement, replacement of customer meters to decrease commercial loss, and leak repair. In addition, it allowed water pressure control by grasping the precise information and selecting suitable solutions. The Asset Management Unit acquired the practical knowledge to manage the information necessary for effective water distribution management. Regarding GIS-related activities, the map information stored on MapInfo was accumulated through the project activities.

Leaders of the NRW Unit and Asset Management Unit acquired sufficient knowledge and skills on water distribution management and information management on distribution pipelines, respectively, and became highly capable of providing internal training on water distribution management to other SWA staff.

The SWA developed and authorized an SOP for leak detection that comprised six sub-topics. Further, internal training and technical examinations were regularly conducted with the support of JICA experts. Through technical cooperation project activities, SWA's counterpart personnel acquired the knowledge and skills regarding a series of leak detection work, including appropriate use of equipment; procedures; and actual practise of leak detection surveys as well as reporting methods. Notably, they improved the accuracy of detecting water leakage by acquiring the proper operation skills of using leak detection equipment and ultrasonic flow meters. Utilizing such equipment, the leak detection unit successfully determined the water leakage location in the transmission line. Moreover, this revealed the entire leakage amount, including the locations of water leakage in the main and sub-main pipes in the two DMAs, which accounted for approximately 70 per cent of the leakage amount in the Alaoa Water District. Grasping the precise condition of DMAs enabled the SWA staff to prepare a replacement plan for deteriorated pipelines, based on the specific evidence, by prioritizing the pipes to be replaced. Through the project activities, the staff at the water quality unit began to pay more attention to water quality in the water treatment process at the plant. The SWA staff immediately informed the WTP operators and provided advice on chemical dosing when any abnormal values were detected on the tested items. This is how SWA established a system of providing feedback regarding the results of water quality analysis to the water treatment process, which ensured the provision of safe water to customers. Furthermore, the water quality unit began issuing an annual water quality report from 2017, which presents the water quality trend for each parameter throughout the year. SOPs on water quality management have helped standardize O&M procedures at the Alaoa WTP. The SWA staff at the WTP's O&M department understood the system and functions of water treatment

and began regularly removing accumulated sludge in the sedimentation basin and the roughing filter units. SOPs are also standardized to control appropriate water flow within the water intake limitation when turbidity is high. This activity contributed to a decrease in the frequency of sand filter scrapings. In addition, the plant operators managed to maintain the chlorine dosing facility appropriately, which contributed to a decline in the detection of *E. coli* and total coliforms in treated water.

It was found, at the end of the project, that the human resource capacity at SWA was limited to integrating training sessions, which were delivered under the project into SWA's annual training plan and institutionalized in the internal training system. Therefore, SWA included planning and implementation of OJT to staff several times a year in engineers' and engineering officers' job descriptions and continued their training system.

In interviews with SWA staff, JICA has confirmed that the results described above continue to be achieved until 2021, including the sustained improvement of water services through the use of SOPs by SWA.

In contrast, there were remaining challenges, especially with pipework. The high NRW ratio in the service area of SWA was due to poor pipework. Most of the water pipe leaks that account for over 90 per cent of NRW were attributed to poor quality work, such as omission of protective sand, insufficient pipe burial depths, and sloppy pipe jointing. In order to improve these problems, SOPs have been formulated and a series of training programmes have been carried out through the project. Although the situation has tremendously improved, leakages from some of the recently renewed pipework were still found, which were the result of shoddy and self-directed work procedures. Considering such cases, it might be advisable for the team leaders to supervise and ensure all the SOPs are followed by the workers during the construction of pipelines, in addition to providing training on SOPs.

Finally, we conducted a training session for maintenance staff by showing a video of the SOP for the electrofusion of polyethylene pipe as a trial and the results were acceptable. It seems that remote training would also be effective if the methods and materials of remote training are developed and enhanced in the future.

Conclusions

Users are not willing to pay for insufficient quality of service for water supply. In addition, due to the financial status of the water utilities, increasing the water tariff would be unacceptable. The integrated cooperation to improve the water supply service in Samoa adopted a bottom-up approach by enhancing the capacity of the SWA staff as well as developing hardware through a grant aid project. To tackle the high NRW ratio, low water supply quality, and inappropriate water supply pressure, a number of SOPs for each subject were developed, and through continuous on-the-job training, the capacity of SWA staff was improved under the guidance of experts from Okinawa Islands. Consequently, the NRW ratio, which was 68 per cent in 2014, was reduced to 36 per cent in 2019. The proportion of taps meeting the appropriate water pressure was nearly

85 per cent, and the water supply, in which many *E. coli* were previously detected, achieved 100 per cent compliance with water quality standards during the last phase of the activities.

Thus, an integrated approach involving hardware support and the capacity development of SWA staff was linked to the improvement of water services. Through such improvements in water services, the shift to a metered water system, which resulted in a substantial increase in tariff revenue, succeeded in gaining the users' understanding regarding payment. Financial balance in the SWA's operations was achieved, from a negative S$4.7 m in 2012 to a positive S$4.7 m in 2017. Through such cooperation activities, SWA began to grasp the condition of its water supply system by measuring specific parameters. Subsequently, quantitative goals could be set by SWA, and the priority area on the measures was determined. Consequently, the SWA staff was motivated by the quantitative and visible results after the implementation of the measures. As of 2021, JICA has started a new technical cooperation project through WOP to build an internal training system within SWA, to extend the results achieved in Apia City to other areas in Samoa.

References

Akram, A.A., Olmstead, S.M. and Olmstead, S.M. (2011) 'The value of household water service quality in Lahore, Pakistan', *Environmental and Resource Economics* 49(2): 173–198 <https://doi.org/10.1007/s10640-010-9429-7>.

Asim, S. and Lohano, H.D. (2015) 'Households' willingness to pay for improved tap water services in Karachi, Pakistan', *Pakistan Development Review* 54(4): 507–524 <https://doi.org/10.30541/v54i4I-IIpp.507-526>.

Fakhruddin, S.H.M., Babel, M.S. and Kawasaki, A. (2015) 'Assessing the vulnerability of infrastructure to climate change on the islands of Samoa', *Natural Hazards and Earth System Sciences* 15(6): 1343–1356 <https://doi.org/10.5194/nhess-15-1343-2015>.

JICA (2019) *Joint Terminal Evaluation Report Capacity Enhancement Project for Samoa Water Authority in Cooperation with Okinawa (CEPSO) in the Independent State of Samoa*, JICA, Tokyo.

JICA and Yachiyo Engineering (2014) *Preparatory Survey Report for Consolidated Urban Untreated Water Supply Schemes Rehabilitation Project in the Independent State of Samoa, Final Report* [pdf], JICA, Tokyo <https://libopac.jica.go.jp/images/report/12146775_01.pdf> [accessed 9 July 2021].

Keen, M. (2003) 'Integrated water management in the south pacific: Policy, institutional and socio-cultural dimensions', *Water Policy* 5(2): 147–164 <https://doi.org/10.2166/wp.2003.0009>.

Latū, F., Amosa, P., Imo, T. and Taufao, V. (2012) 'The microbiological survey of potential water borne pathogens in fresh water springs of the selected community located in the Upolu Island, Samoa', *International Journal of Environmental Science and Development* 3(2): 89–93 <https://doi.org/10.7763/IJESD.2012.V3.194>.

Mosley, L.M., Sharp, D.S. and Singh, S. (2004) 'Effects of a tropical cyclone on the drinking-water quality of a remote pacific island', *Disasters* 28(4): 405–417 <https://doi.org/10.1111/j.0361-3666.2004.00266.x>.

Tussupova, K., Berndtsson, R., Bramryd, T. and Beisenova, R. (2015) 'Investigating willingness to pay to improve water supply services: Application of contingent valuation method', *Water (Basel)* 7(12): 3024–3039 <https://doi.org/10.3390/w7063024>.

WHO and UNICEF (2021) *Joint Monitoring Programme (JMP) Progress on Household Drinking Water, Sanitation and Hygiene 2000–2020: Five Years into SDGs* [pdf], WHO and UNICEF, Geneva <https://washdata.org/sites/default/files/2021-07/jmp-2021-wash-households.pdf> [accessed 1 September 2021].