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Possible Solutions to the Challenges of Domestic Water Pricing for Mandalay City

Tin Nwe Nwe Htun[a]*, Nilar Aye[b]

[a,b]*Department of Civil Engineering, Mandalay Technological University, The Republic of the Union of Myanmar*

[a]*Email: zalatphyu09@gmail.com*

[b]*Email: dnilaraye@gmail.com*

Abstract

This paper focuses on the possible solutions to the challenges of domestic water pricing in Mandalay City. The current water pricing of Mandalay City is necessary to reform as they cannot cover the operation and maintenance cost of the supply system and cannot expand the water network to the unconnected households. For reforming water pricing, the challenges of domestic water pricing for Mandalay City are identified as eight major challenges based on previous study. For reforming water price, questionnaire survey is done to 286 households from six townships of Mandalay City to know the willingness to pay (WTP) of consumers and price elasticity of domestic water demand is evaluated by using mid-point formula. To solve the challenges of water infrastructure deterioration, public-private- people-partnership (4P) is proposed as one of possible solutions for financial efficiency of the supply system. For reducing non-revenue water (NRW), field survey is done in Daewon ward of Mandalay City as a pilot area to investigate the causes of water losses and then possible solutions are proposed. The possible solutions for remaining six challenges are proposed by studying the secondary academic sources such as papers, journals, and books. In this paper, eight numbers of possible solutions are proposed for the challenges of domestic water pricing in Mandalay City.

Keywords: domestic water pricing; challenges; possible solutions; Mandalay City.

1. Introduction

Every human being, present and future, should have access to safe water. Water is the basis for all living ecosystems and habitats and part of an immutable hydrological cycle. It must be respected if the development of human activity and wellbeing is to be sustainable.

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* Corresponding author.

During the latter half of this century, the pressure on natural water resources in many regions of the world has been increasing dramatically. Two-thirds of water consumption already goes to irrigation and agricultural needs are increasing. Meanwhile, industrialization is also taking a heavy toll on our fragile water supplies, creating both new demands and risks of pollution. The standard response to water scarcity is to increase water supply. For water management, the shift is from a supply orientation to emphasis on demand side management. An essential component of demand side management strategy is water pricing. The role of water pricing for managing water resources is widely recognized in many areas of the world. It can contribute to higher water use efficiency and can provide financial resources for investing new water resources infrastructure and for sustaining the operation and maintenance of the existing water infrastructure. In the study area, the existing water supply system is mainly carried out by municipal water supply organization. But, water tariffs cannot recover the operating and maintaining cost of the system. The lower water tariff may lead to water over consumption and large quantity of wastewater discharge result in high pressure on the water environment. The more water tariffs were needed to recover the operating and maintaining cost and to improve the existing water supply system. Some parts of water distribution infrastructure are becoming deteriorated as lack of regular maintenance, poor quality repairs and financial inefficiency of the supply system. Higher non-revenue water (NRW) is another challenge that it threaten to water utility. Mandalay city water supply system needs to improve effectively. Therefore, this study intends to find possible solutions of challenges to domestic water pricing and that it should be supported for the Myanmar National Water Policy in order that the Myanmar Water Law can be enacted.

2. The Study Area

Mandalay city is located in the central region of Myanmar at 21° 58' N 96° 04' E. It is also the second largest city and the last royal capital of Myanmar. It is located 445 miles north of Yangon and bordered by the Ayeyarwady river at the west. The city has an estimated population of 1.3 million and is the capital of Mandalay Region. Mandalay is the main commercial, educational, health and economic hub of Upper Myanmar and considered as the center of Buddhism in Myanmar. In the study area, there are six downtown townships namely, Aung Myae Tharsan, Chan Aye Tharsan, Mahar Aung Myae, Pyi Gyi Tagon and Amarapura township. The location map of the study area is shown in figure 1.

2.1 Water product1ion and water coverage of the study area

The present water supply system is managed by the water supply and sanitation department of Mandalay City Development Committee (MCDC). The primary water source of MCDC water supply system is groundwater and surface water. 90% of groundwater and 10% of surface water is used for water distribution. There are 10 Booster Pumping Stations (BPS) and the average daily water production is 30 million gallons per day. Average distribution from surface water is three million gallons per day and from ground water is 27 million gallons per day. Total water requirement for the whole area is about 37 million gallons per day. However, public water supply covers only 70 percent of urban population [4]. The location map of booster pumping stations is shown in figure 2.

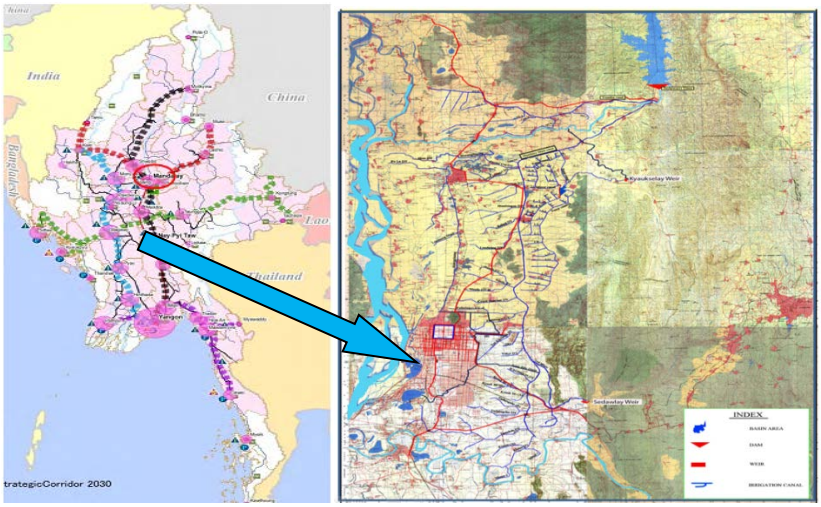
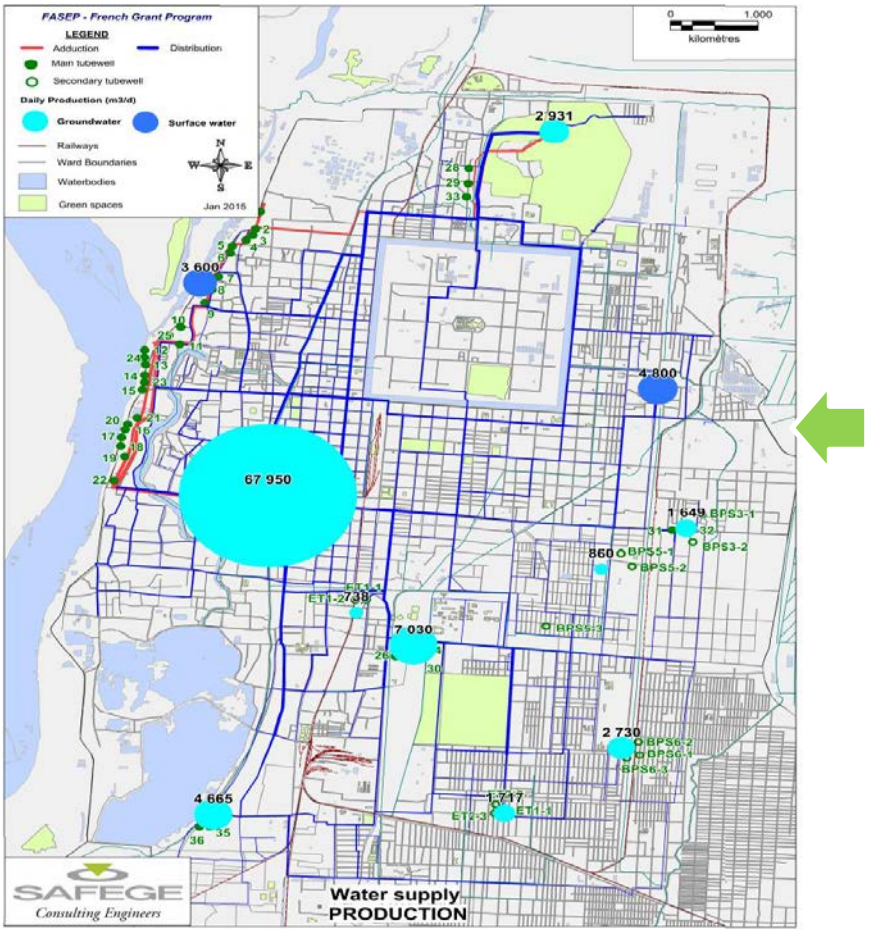


Figure 1: Location map of the study area



Daily Water Production of MCDC Water Supply System

Total production

1,36,363.64 m3/d (30 MGD)

Surface water

13,636.36 m3/d (3 MGD)

Ground water

1,22,727.27 m3/d (27 MGD)

Figure 2: Layout plan for daily water production of Mandalay City water supply system

2.2 Water consumption of the study area

In practice, it is difficult to estimate the volume of water used by households. In this study, water consumption is determined by measuring the volume of water storage facilities available in the house and estimating how much of the storage capacity is used on a day-to-day basis [1]. The average monthly consumption of water for household is 23.28 m^3 per month from a minimum range of 3.30 m^3 to a maximum range of 52.86 m^3 per month (from author survey).

2.3 Water price in study area

The history of water price is simple and Table 1 shows the history of water price in Mandalay. The current unit rate of water is uniform rate structure.

Table 1: The history of water price

Year	Water Rate (MMK/units)	Water Consumption (m^3)
1990-1996	5	≤ 90
1990-1996	10	> 90
1996-2005	10	≤ 90
1996-2005	15	> 90
2005-2007	25	≤ 90
2005-2007	30	> 90
2007-2010	55	No range for water consumption
2010-2015	55 (for residential use)	No range for water consumption
2010-2015	77 (for commercial use)	No range for water consumption
2015-2017(March)	85 (for residential use)	No range for water consumption
2015-2017 (March)	110 (for Commercial use)	No range for water consumption

Source from Mandalay City Development Committee (MCDC)

3. Methodology

In this study, eight major challenges are identified for domestic water pricing of Mandalay City. Situational analysis of existing water supply system is carried out to investigate the deteriorating infrastructures. For reducing non-revenue water amount, field survey is done in a pilot area to assess physical and commercial losses of the supply system.

Based on these situational analyses, the suitable solutions are proposed for the study area. For the challenges of low water price, price elasticity of domestic water demand is evaluated using willingness to pay approach and then the new water prices are set up.

Questionnaire survey has been conducted to achieve the willing to pay and the perception of water pricing from 286 households of the study area. The secondary academic sources such as paper, journals and books are used to propose the possible solutions for other challenges. Moreover, international solutions for water management help to get the possible solutions of domestic water pricing in Mandalay City.

4. Major challenges

Based on questionnaire survey and literature, the following major challenges to the domestic water pricing in Mandalay City are identified.

1. Deterioration of infrastructure in water supply System
2. High Non-Revenue Water (NRW) amount
3. Low Water Price
4. Poverty and affordability challenges
5. Lack of Public Private Partnerships
6. Poor laws and regulation for ground water extraction
7. Lack of awareness for water conservation
8. Climate Change Challenges

5. Possible solutions to the domestic water pricing of Mandalay City

5.1 Possible solutions for the deterioration of infrastructure

As the piped water supply system of Mandalay was mainly constructed between 1983 and 1992 under a project financed by the Asian Development Bank (ADB), the current water supply system is over 30 years old. The existing piped water supply system consists of tube wells, booster pumping stations, distribution reservoirs and distribution pipe lines. Protecting the infrastructure used to treat and transport water (including sources, treatment plants and distribution systems) is an important step in ensuring the safety of water supply. However, in piped water supply system of Mandalay City there has been neglected many years of maintenance to water storage, treatment and distribution system. Therefore, most of the parts are becoming deteriorated due to system aging, corrosion, poor quality repairs, lack of regular maintenance and water employee's insufficient knowledge. The burst water pipe and broken parts of the supply system in the study area is presented in figure 3.

Figure 3: Burst water pipe of supply system

The civil work can also damage to buried pipe due to excavation by a contractor. Due to urbanization and population increasing of the study area, other infrastructure such as urban road and drainage system are also necessary. Roads and Bridges Department under Mandalay City Development Committee (MCDC) is carrying

out for these projects. Due to the lack of coordination with the water utility, the construction machine such as backhoeing causes the pipeline broken buried in ground. To avoid these problems, integration of each other department is necessary to know the information of pipe layout buried in ground. Water leakage and pressure fluctuation that the pressure is too high near the BPS and is too low away from booster pumping station (BPS) are the most serious problems in the existing water supply system. Thus, the current water supply system is necessary to replace and upgrade the deteriorating water infrastructure.

To solve the deterioration of water distribution infrastructure, the following solutions are proposed to the water utility of Mandalay City.

(1) District Metering Areas (DMAs) should be used to control the pressure, to find the water losses of the system, to know the location of damaged pipes and to effectively carry out the operation and maintenance work of the system.
(2) Automatic Pressure Reducing Valves (PRVs) should be used to control the pressure problems.
(3) The consumer's pumps that connect directly to the networks must be prohibited by laws.
(4) For the regular maintenance of the system, a master plan should be developed for the network and updated every few years. The master plan should look forward to identify risks and trends in the system and consider operational plans and system expansion.
(5) Regular monitoring and inspecting of the system is necessary. Consumer's reported and discovered component failures of the system should be repaired as soon as possible. Thus, community involvement in the water supply system is also important to get the information of the system.

Moreover, Proper training and capacity building of the staff is essential for effective maintenance of the water supply system as the lack of professionals and staff training leads to deteriorate infrastructure. For financing the projects, water utility is carrying out by integrating the private sector in currently for improving water distribution infrastructure. For publicly own water systems, the use of Public Private Partnership (PPPs) can provide access to private financing for infrastructure projects. For the potential use of PPPs, municipal water utility needs to address a number of important concerns particularly about the PPP's accountability to the public before entering into such an agreement. Moreover, People Public Private Partnerships (4P) is more appropriate than 3P because only private sector participation can focus on their economic benefits of the system.

5.2 Possible solutions for the reduction of high Non-Revenue Water (NRW) amount

In the study area, water utility faces NRW problem. According to the record, the percentage of NRW was 32% in 2010-2012 data, 75% in 2014 from JICA estimation, 50 % from FASEP interception report and 46% of system input in 2015 [2]. As the existing water utility operates their pipe network as an open system where water is fed from more than one Water Treatment Plant (WTP) into an inter-connected pipe network, NRW can only be calculated for the entire network which is effectively an average level for the entire system. Thus the water utility faces a challenge for the network in determining the exact location of NRW occurrences and where NRW reduction activities should take place. The supply system needs to split into hydraulically small zones called District Metering Areas (DMAs). The smaller the zone, the more information of the leakage can get.

Moreover, NRW control team should be composed to effectively carry out for reducing NRW.

In this study, a pilot area is chosen to determine the NRW amount. East Daewon Ward from Maharaungmyay township is chosen as a pilot area because a flow meter was already installed at this area. The location map of the pilot area is shown in figure 4.

Figure 4: Location map of pilot area

Field survey is done to know the causes and physical and commercial losses of NRW. According to the field survey within the pilot area, it was found that the system losses where service pipes connected to the distribution main is shown in figure 5. Figure 6 shows the lack of meter maintenance in the pilot area.

Figure 5: Physical water losses at the pilot area

Figure 6: Lack of meter maintenance

The calculation period of NRW for the study area is one month. The total inflow and billed consumption data are collected within one month and the total service connection is 234 numbers. Water balance is used to asses NRW and Top-Down approach is used for splitting apparent and real losses. System input for pilot area is 9727 m^3/month. Billed metered consumption is 8125 m^3/month. FOC (unbilled meter) is 1 numbers. Error meter is 20 numbers. Closed meter is 8 numbers. An average Meter accuracy loss is 8.54%. According to the results of

water balance, the component of NRW for the pilot area are unbilled authorized consumption is 31 m^3/month, Commercial losses is 837 m^3/month, Physical losses is 713 m^3/month and NRW for pilot area is 1581 m^3/month.

According to the field survey of pilot area, the life of water meters is over 20 year's age because these meters were set up after the completion of water supply project. Most of the meters do not work functionally and some of them are broken. Some meters cannot be read due to the lack of properly maintenance. Therefore, for reducing commercial losses of the pilot area, the following solutions are proposed;

(1) The utility should replace the meter systematically, beginning with the oldest meters and those in the worst condition. A scheduled maintenance and replacement program should be in place to manage this problem.

(2) All meters should be installed above ground and located where they can be audited easily including by the meter readers during their regular rounds.

(3) For sizing meter properly, utility should conduct customer surveys to understand the nature of each customer's water demand and their likely consumption. This information helps to determine the proper meter size for household and businesses. For customers with higher water demand, it is necessary to check the flow pattern and to install the new meters. Choosing the appropriate meter helps to ensure the accuracy of customer consumption data.

(4) Water utility should invest in training and motivating their meter readers to record and report information effectively and efficiently as meter reading activities have and immediate impact on cash flow.

For reducing physical losses of the pilot area, the following solutions are proposed;

(1) NRW control team immediately repairs the visible leakage and replaces the new ones to damaging pipe.
(2) To detect the invisible leakage of underground pipe, water utility require the acoustic equipment such as noise loggers, leak noise correlators, ground microphones and sounding sticks because the basic method of detecting and locating a leak is to listen for the noise of water being released from the pipe under pressure. Once a leak is detected, repairs should be completed as soon as possible to limit the water losses [8].

To know the information of illegal connection, promoting the knowledge deal with NRW and letting to know the operation of water supply system to the customers are very important roles. Illegal connection to the distribution pipes must be punished by laws. Therefore, to control NRW of MCDC the whole water supply system, there is also need not only technical measures but also legal and institutional arrangement. For the study area, starting from DMAs to demonstrate the effectiveness of the NRW strategy should be useful as it needs to take long term action because the development of NRW reduction strategy based on the concept of awareness

time, location time and repair time (ALR). Moreover other financial supports need to repair leaks and bursts, flow meter installation charges and for purchasing other leakage detecting device.

5.3 Possible solutions for low water tariff

The water tariff structure should be sufficient to cover O&M costs, enable debt servicing, and support developments plans. Moreover, water pricing must enable all people regardless of whether they are low-income or high-income earners to afford the water for basic needs. For domestic water pricing, the water price should be based on fair and equal principle. The fair and equal principle requires to consider the affordability and willingness-to-pay of users [7]. Therefore, to set the new water price for the study area, the price elasticity of water demand for the study area was evaluated by using willingness to pay analysis.

Social economic survey, water consumption and willingness to pay of the households are previously done for the study area. Based on the estimation of price elasticity values using willingness to pay (WTP), the unit price for domestic water can be set up the minimum value is 195 MMK/unit and the maximum value is 233 MMK/unit. The maximum willingness to pay for water price is 252 MMK/unit. By using these values, the existing water supply system can be able to increase financial efficiency.

The current water rate structure in Mandalay is uniform rate and is divided the tariff into residential uses and commercial uses. The historical water prices till to 2017 (March) cannot cover the unit production of water. Therefore, the water utility increase the water rate as 200 MMK/unit for residential uses and 260 MMK/unit for commercial uses starting from 2017 (April). Although the new water tariff is sufficient for the unit production cost of water, the financial revenue is still not enough due to the higher non-revenue water. Therefore, the possible solution for the reduction of non-revenue water is previously proposed in this paper. Moreover, seasonal water rate structure is proposed for water tariff due to the dry climate effect of the study area. One advantage of implementation of seasonal rate is to promote consumer's water conservation.

Customer service is also very important for MCDC water utilities to provide good service to customers and make continuous improvements. This service should include a better billing system, an efficient call center, quick provision of service and quick response to customer enquiry, etc. Transparency for the supply system is also very important to the customer to get clear information about any issues related to the cost of water service such as how much money the government spends on water investments and what the objectives are behind the increase tariff. After reforming the water tariffs, the water utility needs to support the improved water services to the customer such as 24 hours water supply services and good water quality because the existing water quality is very bad in some places of the study area.

5.4 Possible solutions for poverty and affordability of water service

In reforming water pricing, water utility must also consider affordability and the access of urban poor to piped water supply system. In the study area, water and poverty is linked by the two factors such as insufficient network service and connection fee. In order to achieve water service to the poor households, government subsidy is necessary. These subsidies can be financed in two principal ways such as supply-side subsidies and

demand-side subsidies and the schematic representation of direct subsidies is shown in figure 7.

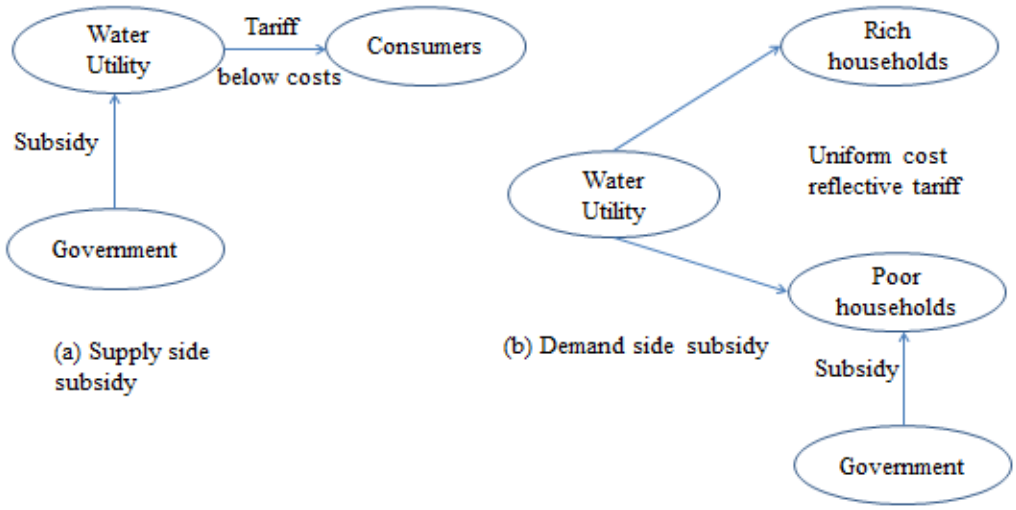


Figure 7: Schematic Representation of direct subsidies

Supply-side subsidies have been the traditional approach used to subsidize water utilities and these resources can be transferred directly to the utility and delivered to consumers through the tariff structure. Alternatively, government subsidy can be given directly to individual customers who are deemed to be eligible for special financial support known as demand-side subsidies; this is generally done outside of the tariff framework. On the other hand, supply-side subsidies tend to lower the general tariff level for all customers and hence often fail to reach the poor. For these reason, if subsidies are supplied in water sector, there is a growing preference for demand-side subsidies that go directly towards covering the water-bill of the poor household rather than general budget support for the utility [8]. Water utility should allow connection fees to be paid over a periods of years by bundling them with tariffs like monthly pay system.

Alternatively, small scale water provider (SSWP) should be considered to provide water service to the urban poor as they can provide water service with lower connection fee. But the water services of SSWP are not recognized under government and local water utility. Therefore, water utility should register to the SSWP and give license and collect tax for their service. And then, it is necessary to monitor the set of water tariff and the water quality. Rainwater harvesting can also be a solution for the lack of water services for urban poor. It is one of the ancient methods for collecting water from roofs, cisterns and other sources and the runoff should be diverted into ponds and reservoirs for urban areas of Mandalay and it is also useful for domestic use.

5.5 Possible solutions for lack of public-private Partnerships (PPPs)

For the development of the process of PPPs, the water utility needs to perform three steps. The first is the creation of public utility with a regulatory body; the second is the addition of domestic private sector participation (PSP) with a regulatory body and third is the addition of international PSP with a regulatory body. For the addition of international PSP, a host country's legal framework should be considered and the host country needs to address an openness, transparency and accountability for the water supply system. Water

utility needs to establish a state-owned enterprise reform unit for the introduction of private sector investment in water supply.

The unit should consist of a team of trained individuals with expertise in economics, management and finance, water supply, negotiation and stakeholders. The existing water supply system carry outs for the system improving by coordinating with the some international private partners such as with Japan International Cooperation Agency (JICA) for expanding Pyigyitagon water supply network, with Asian Development Bank (ADB) for downtown four townships water supply and with Agence Francaise Development (AFD) for Amarapura township water supply and they are now under processing. Water utility should invite the domestic private partners as it can provide good human resources management and financial expertise. PPP is a contract normally between the government and private sector.

According to UN Report (2005), there are many options available in a PPP contract and each of them has varying characteristics and responsibilities. These are service and management contracts, leases, operations and maintenance concessions [11].

Service contracts

Service contracts refer to arrangements whereby the public authority retains responsibility for operation and maintenance of the system, but where specific activities of the system are contracted out to private sector for a fee. Service contracts usually have duration of six months to two years. The main benefits include having private sector expertise, focused on that particular activity as well as being a driver for efficiency achieved through the tendering process.

Management contracts

In management contracts, the private firm takes responsibility for operations and maintenance of the wider system or parts of the system for a fee. The public authority retains ownership of assets and investments in the system. It usually has duration of three to five years.

Lease contracts

Under the leases approach, the lesser (private operator) rents the facility from the public authority and becomes responsible for operating, maintaining and managing the system. The public authority remains responsible for new investment into the system. The private operator pays a fee for the use of assets. The operator also bears the commercial risk. The duration of the contract is between eight to fifteen years. The leasing contracts are administratively demanding such as setting and monitoring the performance targets and the use of assets.

Build operate transfer (BOT) or Build own operate transfer (BOOT) contracts

These contracts are generally used to construct new systems or parts of the system such as water treatment plants and wastewater treatment plants. The private operator builds the plant and assumes responsibility for

operation and maintenance in exchange for a fee, which is usually related to the volume of water supplied or treated. After a predetermined time, the facility is transferred back to the public authority.

Concession Arrangement

In the concession arrangement, the concessionaire (private operator) has overall responsibility for services, including operation, maintenance and managements as well as capital investments during the concession period, carrying all commercial risks for construction of fixed assets, operating and maintaining those assets in exchange for tariffs which the concessionaire is also responsible for collecting. Ownership of the fixed assets remains with the public authority. The duration is between twenty and thirty years to ensure a reasonable return to the concessionaire on the capital invested in new works.

Based on the government's intension to make the required improvements in water services, the appropriate option should be used. Alternatively, water utility must consider the existing small scale water provider (SSWPs) in PPPs. SSWPs provide more flexible arrangements for connections and payments than water utilities, leading to better relations with customers. Especially in some unauthorized settlements, a large percentage of people draw their water from the SSWPs. But, SSWPs are not formally recognized by utilities or local government. Therefore, officials need to learn more by auditing existing utilities and SSWPs so that they can be registered and recognized. Moreover, only private sector participation in the water supply system can cause inequality as the private sector can focus on their economic benefits from the system. Therefore, participation of people is an important role in reforming water sector and the implementation of public-private-people-partnerships (4P) is suitable for the study area.

5.6 Possible solutions for lack of laws and regulations for groundwater extraction

The 1930 Burma Underground Water Act is the current legal provision but it is not applied properly and requires many amendments to reflect the current situation. The British government enacted the law to support sustainable use of groundwater. They also supported a water officer to monitor its use and to issue licenses to pump groundwater after checking to make sure it would not damage the environment. Except Yangon City Development Committee (YCDC), other water utility did not apply this law. After 1988, the YCDC was no longer able to provide sufficient water supplies to the city, so residents began digging unlicensed tube wells. This law has been developed with government departments and experts led by the ministry of Urban and Housing Development department since 2014. This law will be sent to the cabinet and to the Hluttaw. Therefore, a law for the conservation of Myanmar underground water resources has been drafted and is hoped to be enacted in the near future [3].

Before enacting the water laws, water utility can establish Water Regulatory Authority (WRA) to monitor groundwater extraction and to develop the groundwater recharge. The regulatory body should comprise people representing the stakeholders, including industrial and domestic consumers, operators and local government. Groundwater regulation requires information on groundwater use at frequent interval. Water utility needs to install mechanical devices to monitor the groundwater resources. Remote sensing technology can be used for

monitoring ground water table. There should be good collaboration between the Universities that makes research and local water utility. In the contents of groundwater regulations, drilling license to ensure environmentally sound drilling, registration of groundwater users based on volume and purposes of use, introduction of charging groundwater use or tax and designation groundwater protection areas should be considered. There is also a need for regulatory measures to control the extraction and sale of ground water by water vendors and industries.

In the study area, as the main water source is groundwater source, other laws and acts such as Groundwater Directive, Water Resources Act, Control of Pollution Act, Local Government (Water Pollution Act), Environmental Protection Act, Water Services Act and Myanmar Communities Act etc., should be enacted for groundwater users [10].

5.7 Possible solutions for lack of awareness for water conservation

For promoting the awareness for water conservation, information and educating to the customers are important and necessary. An information and education program should explain to water users all of the costs involved in supplying water and demonstrate how water conservation practices will provide water users with long term savings. School programs can be a great way to get information out and it can provide information on water conservation and encourage the use of water conservation practices. Contacts through schools can help socialize young people about the value of water and conservation techniques, as well as help systems communicate with parents.

Workshops and seminars can be used to solicit input and water saving equipment manufactures can be invited to these sessions to exhibit their equipment. Moreover, public participation is now widely understood to be a necessary input for both efficiency and equity. Therefore, government and water utility should compose the institutional organization such as Water User Association. WUA monitor to the water user and giving awards and penalty to the customer that use water efficiently and wastefully [9]. Metering is also a most important part for water conservation. Accurate metering can record the water usage of customer and can give the information to the customer for their water uses.

Billing for wastewater disposal can also be expected to become a more significant motivation for reducing water use. Other option to conserve water is seasonal water pricing as the water scarcity is common in dry season. The operating cost of water supply system is much more in dry season than other times due to the electricity shortage and the increasing water demand. Therefore, seasonal water pricing can also be considered for water conservation.

5.8 Possible solutions for climate change challenges

In Myanmar, the dry zone is one of the most climates sensitive and natural resource poor regions and the potential climate change impacts in dry zone are (i) decrease of annual rainfall (ii) raising temperature (iii) lesser inflows into reservoirs and (iv) water scarcity. As the study area is located in the heart of the central dry zone, many households suffer water scarcity and water shortage in dry season. Timely implementation of appropriate

policies by local government and water utility needs to implement climate change adaption and mitigation strategies for water supply. The possible strategies of climate change adaption are found for the study area such as rainwater harvesting, planting trees, reuse and recycle water for water supply sector.

Rainwater harvesting simply involves the process of collecting water from surfaces on which rainfalls, filtering it and preserve it for later use. This water is normally collected from the roof tops and stored in rain-water tanks. It can also reduce the pressure on surface and groundwater resources by decreasing household demand and has been used as a tool to recharge groundwater aquifers. Another possible benefit of rainwater harvesting is mitigation of flooding by capturing rooftop runoff during rainstorms. Storage of rainwater can provide short-term security against periods of low rainfall and the failure or degradation of other water supplies. Therefore, the local authority rules out to set up rainwater harvesting system in houses while Building department of MCDC give a permission to build a house in the study area.

Planting trees can also be a solution for the climate change adaption of the study area. Trees can help to mitigate global warming by sequestering the greenhouse gas carbon-dioxide. When planted in upper watersheds, this process reduces runoff and soil erosion and increase ground water recharge. Awareness program such as public talks should be carried out widely and frequently to the consumers in order to know that planting trees can support the sustainability of water resources.

Reuse and recycling municipal water provides an independent source of water to the consumers. Water reusing allows communities to become less dependent on groundwater and surface water sources, to reduce the water diversion from sensitive ecosystems and make general benefits. . In addition, it can reduce the loads of nutrients from waste water discharges into water ways, thereby reducing pollution and making prevention. The study area has occurred a lot of dying biodiversity in Taungthaman Lake due to untreated waste water disposal. Therefore, water reuse can prevent for this process. Opportunities for reuse and recycling of water should be explored by the water utility to the extent possible because this promotes multiples uses of water and improves water productivity. Efficiently reuse and recycle water process can be supported by collecting effluent charges from consumers.

6. Conclusion

The existing water supply system of the study area needs to improve technical skills, revenue efficiency and to maintain water resources sustainability. Water pricing can provide financial resources that can be directly used for the protection of environment or for sustaining the operation and maintenance of the existing infrastructures. For reforming water pricing of Mandalay City, questionnaire survey is done to know the willingness to pay (WTP) of consumers. Situational analysis of the supply system is done to assess the challenges and possible solutions for domestic water.

The possible solutions for water infrastructure deterioration and reduction of NRW are proposed with respect to the findings from field survey. The new water tariffs for the MCDC water utility are based on fair and equal principle as these values are calculated by using willingness to pay of customers. Affordability to the water services for the poor households is considered by using demand side subsidies. To promote public awareness for

water resources conservation, public talks and education programs are needed to implement frequently.

Therefore, the proposed solutions in this study are intended to improve sustainability of water resources for Mandalay city and it is concluded that these solutions can be supported for the Myanmar National Water Policy in order that the Myanmar National Water Law can be enacted.

7. Recommendations

The recommendations can be drawn from on this study. In this study, Challenges and possible solutions to domestic water pricing are done in city level due to time limitation and scope of research. Thus, domestic water pricing should be done to regional level for Myanmar based on this study. Integrated water resources management (IWRM) course should be instructed in master of water resources engineering level at technological university. For water supply system, price elasticity should be considered from supply side of view. Field survey for domestic water consumption of consumer should be done for the whole city level by official survey teams to get the better results for water uses. Finally, the existing water tariff system of MCDC should be transparency and easy to understand for customers.

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