



Assessment of the potential deployment of prepaid water meters in the Gaza Strip

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ABSTRACT

Palestinian water sector institutions have identified a series of interventions to address the severe water crisis in Gaza both in the short-term and in the long-term. This includes the development of desalination facilities to increase potable water supply, as well as the prioritization of efforts to improve the overall governance and commercial viability of the water sector. With the expected increase in the quality of water services, service providers can advance efforts to improve user collection rates. One key measure, utilized globally, that contributes to improving collection rates is the installation of prepaid water metering devices and systems. The aims of this study are to evaluate the socio-economic, legal and governance, technical, and commercial perspectives of deploying prepaid water meters, both at customer and service provider levels. An iterative process of information-gathering, structured household questionnaire, and consultations with key sector stakeholders were conducted. Based on the results analysis of the household surveys, it was found that out of the total surveyed households who are unwilling to use prepaid water meters, 85% say that the use of prepaid water meters will increase their household's financial burden, while 90% fear that the inability to pay for credit will result in water disconnection. Furthermore, not all service providers can comply with the technical and/or financial requirements needed for the successful implementation of prepaid meters programs, given that only two out of 25 service providers in Gaza have some experience in implementing such programs. Effective implementation of a prepayment system requires an integrated management system that takes into consideration the various social, technical, legal and commercial aspects identified in this analysis. To ensure this, different actions were recommended to be implemented.

Keywords: Prepaid water meters; Socio-economic; Legal; Governance; Water; Gaza Strip; Cost recovery

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1. Introduction

Gaza receives its domestic water needs from limited and mostly unreliable sources. The Coastal Aquifer, Gaza's main water supply, faces serious water quality challenges due to longstanding over-abstraction and resultant brackish water and seawater intrusion, as well as from contamination from untreated wastewater [1]. In 2018, the water consumed for domestic use in the Gaza Strip was only 83 l/c/d, which is lower than the Palestinian water authority (PWA) target of 100 l/c/d [2]. In reality, the 83 l/c/d of water actually delivered was not all potable, and the actual potable water consumption was in the range of 20 l/c/d. The actual water consumption varies noticeably by governorate and locality, based on availability of water supply [3]. Updated figures for 2018 domestic water need and consumption reveal a deficit of over 39 MCM in matching the water needs [4].

Water scarcity has been exacerbated by a range of other factors, including water governance challenges, aging infrastructure, insufficient and unreliable electricity supply to operate water and wastewater facilities, import restrictions on materials and equipment categorized by Israel as “dual-use” items, which cover some 70% of WASH-related equipment, as well as funding shortages for operation and maintenance costs, and investments in new infrastructure [1]. There are 25 water service providers across the Gaza Strip; most of them are municipalities and local councils offering utility services among other municipal services in accordance with the 1997 ministry of local government law. To address the fragmentation of water service provision in Palestine, the 2014 water law was developed, have called for the establishment of larger regional water utilities for water service provision. According to the provisions of this law, the coastal municipalities' water utility (CMWU) was established to act as the regional water service provider for the Gaza Strip. However, transferring water service responsibilities to the CMWU has proven to be slow, despite the law requiring this, and the municipalities continue to evolve on their own [5]. At present, municipalities, acting as water service providers, have joint financial accounts for all their services (water, sanitation, and solid waste), though the water provision accounts for the largest proportion of the total bill value. As such, municipalities derive a significant share of their revenue from water services. Most of water service providers (WSPs) consider conventional water metering has a tendency of being unreliable, inaccurate, and a source of dispute and disquiet among customers. It is one of the fundamental reasons that why WSPs perform poor performance and management, very low revenue collection figures, ineffective maintenance, inaccurate billing and high non-revenue water [6].

A prepaid water meter (PWM) is a device for controlling the volume of customer water usage with a water pulse system [7]. Prepaid water means that the consumer purchases water credit in the form of a prepaid water token. When entered into the user interface unit (located in the consumer's home), the token instructs the water management device to allow a certain amount of water through the meter before closing [8]. PWM can be considered as cost-effective solutions to sustainable water management in that

they have a low cost of acquisition and, by decreasing water usage; capital recovery is possible within months. What's more, PWM systems are able to distribute water equally, based on free water quotas, water balancing and fluctuating demand. Furthermore, prepaid systems are more expensive than conventional metering, this is outweighed by the convenience of financial control, having real-time visibility into consumption via an app or user interface unit, and being able to identify a leak well in advance of its becoming a financial burden [9]. Normally, customers are not mostly interested in the technology. They are looking for good services, reliably delivered at affordable prices, therefore prepaid water meters remain controversial [10]. Municipalities that have implemented prepaid systems are seeing value from the ability to track usage and stop water flow once a limit has been reached. And since devices are tamper-proof, municipalities can curb theft and better manage service delivery in under-served areas [9]. WSPs see it as a way to improve customer relations, revenue, and access to services; critics complain about technical unreliability, high capital and maintenance costs, and a system they see as penalizing poor customers, and encroach people's right to water if they cannot afford advance payment [10].

The publicly managed water supply system in Gaza has been running at a deficit for years. As noted, the main driver of the problem is the sub-optimum user fee collection and cost-recovery rates for municipal services as well as again infrastructure that results in high water losses. It can be speculated that collection rates are attributed to the high poverty rate, dissatisfaction with the quality of services, and the limited technical and regulatory solutions to enforce bill payment. Additionally, service providers face administrative challenges such as limited network monitoring, inefficient billing systems, and limited enforcement of bill payment. Such challenges limit service providers' ability to recover their costs and hence to further invest in network rehabilitation and improvement [11].

Palestinian water sector institutions have identified a series of interventions to address the severe water crisis in Gaza both in the short-term and in the long-term. This includes the development of desalination facilities to increase potable water supply, as well as the prioritization of efforts to improve the overall governance and commercial viability of the water sector. Further, the installation of new water facilities represents an opportunity for improving commercial/financial viability of the sector. With the expected increase in the quality of water services, service providers can advance efforts to improve user collection rates.

One key measure, utilized globally, that contributes to improving collection rates is the installation of prepaid water metering devices and systems. Prepaid water meters (PWMs) are water-metering systems, integrated with service provider management systems, in which the consumer purchases water credit in advance of consuming municipal water supply. Along with their role in increasing revenue collection efficiency, PWMs can reduce the operational costs by reducing the number of meter readers and data entry clerks, as well as their associated operational costs. They allow for online monitoring of water consumption and provide more accurate readings, which

helps in managing and reducing the non-revenue water. PWMs can also assist in clearing the accumulated debts and reduce water consumption, as customers are incentivized to reduce water consumption [10,12,13].

Several Palestinian Authority decisions were issued authorizing the implementation of prepaid water meters and provided general guidelines to the respected authorities. While several service providers have implemented this measure in the West Bank, one small-scale project was executed in Gaza to date, while another is under implementation. The objectives of this study are to evaluate, while considering the current situation in Gaza, the technical, commercial, legal and social feasibility of deploying prepaid water meters, and to assess potential opportunities and risks associated with the successful rollout of PWMs and propose mitigation measures based on lessons learned from similar deployments previously implemented.

2. Water service provision

Service providers across Gaza face daunting challenges, particularly as a result of the difficulty in meeting the ongoing costs of delivering safe and affordable water to rapidly growing populations. One key concern is relevant to the ability and willingness of residents in Gaza to pay for these services, considering the technical, political and economic situation in the Strip. Senior managers of service providers fear that increasing water tariffs to the level required covering the costs of operations and reasonable capital maintenance would be faced with political fallout. The following section provides an overview of water service provision in Gaza, including its key challenges, as a necessary basis for understanding the implications of and considerations for installing prepaid water meters. The installation of prepaid water meters may be one of the core solutions to overcome these existing dilemmas.

2.1. Governance

There are 25 water service providers across the Gaza Strip; most of them are municipalities and local councils offering utility services among other municipal services in accordance with the 1997 ministry of local government law. The 2014 water law was developed, in part, to address the fragmentation of water service provision (in both Gaza and the West Bank) by calling for the establishment of larger regional water utilities for water service provision. However, the aggregation of those service providers has proven to be slow, despite the law requiring this, and service providers continue to evolve on their own. Implementation of the reforms set out in this law has been slow due to an incomplete legal structure, lack of financing, and lack of clarity of rules and responsibilities at local level. While the PWA sees water services as a freestanding activity that should be provided by an independent utility, local government units see water services as part of their allocated responsibilities [4]. Dissimilar understandings of the 2014 water law by stakeholders both at the national and local levels implies that the stakeholder consultation process has not yet resulted in full buy-in, which contributed to the delay in the implementation of the 2014 law and its supporting strategies.

This process is critical in order to effectively advance required infrastructure projects and their sustainable operationalization. At present, municipalities, acting as water service providers, have joint financial accounts for all their services (water, sanitation and solid waste), though the water provision accounts for the largest proportion of the total bill value. As such, municipalities derive a significant share of their revenue from water services. Although few municipalities derive an accounting surplus from their water operations [9], the absence of ring-fencing of water tariff accounts means that water revenues are often diverted to general revenues for other municipal expenses. Therefore, municipalities have limited incentive to separate their water operations as autonomous cost accounting centers. This practice is seen as necessary by municipalities as their overall revenue base is low and weak. On the other hand, according to the Palestinian cabinet decision (No. 13/02/16) of 2013, regarding the procedures to guarantee payment for cost of water by the municipalities and local governments, relevant ministries were instructed to enforce separation of water accounts from other municipal services' accounts. However, the higher operational cost of the short-term low-volume desalination plants, imported water from Mekorot, and other new water and wastewater facilities may create a financial burden on municipalities, which could incentivize municipalities to transfer water service responsibilities to the CMWU. Water sector financing, therefore, is conjoined with the need for municipal finance reform.

2.2. Infrastructure and network coverage

Over 1 billion USD has been invested in the Palestinian water and sanitation sector and, as a result, about 97% of Gaza's population is connected to a piped water supply [5]. High connection rates, however, mask service challenges. The number of domestic connections, for example, has not been matched by sufficient efforts to meter these connections. Many residential buildings, regardless of the number of families residing in them, share one meter and one water connection. Across Gaza, on average, there is a single meter for every 17–20 citizens [3]. Moreover, despite high network coverage, service delivery is intermittent, with large variations in per capita supply between communities. Only 30% of households in Gaza have daily network water supply for limited hours. About 15% of the population in Gaza has access to piped water supply for less than 10 d a month supply [5]. This is attributed to several factors including limitations on water supply quantities and qualities as well as on capacity limitations of the transmission and distribution networks. Plans to upgrade and rehabilitate the networks are underway to enable the system to absorb the additional planned water quantities.

2.3. Operations

The publicly managed water supply system in Gaza has been running at a deficit for years. As noted, the main driver of the problem is the sub-optimum user fee collection and cost-recovery rates for municipal services as well as again infrastructure that results in high water losses.

In Gaza, tariffs cover two-thirds of operational costs on average; meanwhile, water service providers collect only 37 cents on each dollar of sales. As a result, the average service provider covers less than 24% of its incurred costs. In 2014, for example, Gaza service providers incurred an average shortfall of 2.01 NIS (0.7 USD) for every cubic meter supplied [5]. High non-revenue water rates, together with low tariffs and low collection rates, mean that the service providers run persisting financial deficits and most are not able to cover operation and maintenance (O&M) costs. Improvements in non-revenue water were reported between 2015 and 2016; for example, the rate went down from 58% to 41% in Wadi Gaza, from 58% to 19% in Al Mughraqa, and from 56% to 35% in Beit Hanoun. Khan Younis achieved a marked improvement as well, going from 40% in 2015 to 26% in 2016 [3]. These reductions are largely due to improvement in maintenance of the system and in meter readings as well as repairs to the network that were damaged by the 2014 war; however, further improvements are still needed to enable sustainable operations. Implementing the PWA's rolling plan of investments (880 million USD) in the period leading up to 2030 is expected to significantly increase operations and maintenance costs in Gaza from 68–118 million USD/y depending on the energy source for facility operation [14].

Without careful planning, institutional and tariff reform, advancing this infrastructure will lead to a mounting O&M-related financing deficit. For these projected future O&M costs to be covered, tariffs would have to increase between 0.8–1.4 USD/m³; such increase in tariff would mean that households in deep poverty would be spending 5% or more of their income on water bills [15]. Based on 2016 prices, this would be a 280–350% increase in the average consumer tariff. As around a third of households in Gaza fall into the 'deep poverty' category, this would have to be managed through cross-subsidies or social safety-nets [16]. The cost of O&M is highly associated with the cost of power used to energize these facilities, depending on whether they will run on electricity from the grid, renewable energy, natural gas, and/ or to diesel. It is estimated that the Gaza water sector will require 137.8 MW by 2030, including 35 MW for Phase I of the Gaza central desalination plant and associated works [5].

2.4. Billing and collection

There are three main mechanisms for issuing and collecting water bills that service providers are using in the Gaza Strip. These mechanisms can be summarized as follows:

- The municipality is responsible for issuing the bill and collecting the revenue, while CMWU has no intervention. This mechanism applies for eleven municipalities: Gaza City, Khan Younis, Al Burajj, Al Nusairat, Abasan al Jadeeda, Abasan al Kabeera, al Qarara, Al Fukhari, Al Naser, Beit Hanon, and Beit Lahia municipalities.
- CMWU is responsible for issuing the bill and collecting the revenue in Rafah.
- CMWU is responsible for issuing the bill while the municipality is responsible for collecting the revenue.

This applies for the remaining thirteen municipalities in the Gaza Strip. In this case, CMWU receives 10% of the total collected bills.

An average of about 30% collection efficiency is recorded by the service providers in the Gaza Strip [8]. Such low rate is a reflection of the level of readiness (willingness and/or affordability) of consumers to pay their dues, in addition to the efficiency of service providers to advance bill collections. It is important to also consider the cultural context in the Gaza Strip, where residents have limited incentive to pay for public services, which is further encouraged by the absence of punitive actions against non-bill payment. Moreover, the already low rates have also been severely affected by the deteriorated economic situation in the past few years. Service providers are taking various measures to increase collection efficiency. These methods include awareness campaigns to change customers' payment behavior and door-to-door collection campaigns. Moreover, many municipalities apply policies of incentive discounts on accumulated debts to encourage customers to settle their debts.

3. Material and methods

The methodology was designed to ensure broad participation of actors active in the water sector. The data collection process began with a desk study of relevant documents about the sector, including laws, strategies and sector reports, and publications pro- and anti-prepaid water meters. In coordination with PWA, collection of all available quantitative, qualitative and spatial data, as well as all related documents, have taken place to design and develop data collection tools needed for performing the study. Running parallel to the desk study, several in-depth interviews were conducted with major stakeholders, including the PWA, CMWU, five municipalities in the Gaza Strip (Rafah, Khan Younis, Nusairat, Gaza and Beit Lahia), two service providers in the West Bank, and Gaza electricity distribution company (GEDCo), which has been assessing the feasibility of prepaid meters as a cost recovery measure for several years. Herewith, the utilized methods are summarized as follows:

- Semi-structured question guides were developed and used, as open-ended questions, in order to collect information from major stakeholders to achieve the study objectives. Furthermore, a structured questionnaire was developed for households. The total number of water service subscribers is about 165,000 subscribers [8].
- A representative sample of 447 households, located in 12 communities across the Gaza Strip, was chosen for allocating the questionnaire. Data was collected by combining two sampling systems: (1) cluster sampling, where each governorate was considered as a cluster with a specific number of water connections, and then (2) random sampling, which was applied as a final step to select the exact number of households to be interviewed in 12 communities distributed within the five governorates. The questionnaire was developed in the Arabic language, as the native language in

Gaza. The questionnaire was designed to find out people's perceptions and attitudes towards using PWMs. It consisted defined sections relevant to the socio-demographic and general characteristics; household economic characteristics; prepaid water meter preference; and understanding of health and social impacts.

- The statistical package for the social sciences (SPSS) software package was used for analyzing questionnaires.

4. Results and discussion

This section demonstrates findings from primary and secondary data collection undertaken. This includes experiences and recommendations from interviews undertaken with key stakeholders in Gaza and the West Bank. Additionally, this section illustrates key results of the household questionnaire and further analysis to understand the data. The analysis undertaken on the collected data considers key aspects and requirements that need to be explored to assess the feasibility of installing prepaid meters as a measure to improve cost recovery. These aspects include the socio-economic highlights; legal and governance pre-requisites and enablers; readiness of water service providers in Gaza; and the commercial and technical suitability of the prepaid technology for the Gaza market.

4.1. Socioeconomic status

This section presents the analysis of the quantitative data collected through the structured questionnaire that targeted a sample of 447 persons across the Gaza Strip. About 74% of the surveyed households have a family size larger than five persons. In 63% of the surveyed households, either the male, female, or both heads of the household are educated. In 68% of households either the male, female, or both heads of the household are employed with a fixed income. In 8.5% of the surveyed households, both the male and female heads are unemployed, while 32% have either the male, female, or both heads unemployed. In 10% of households, either the male, female, or both heads of the household are self-employed. The majority of the respondents (~79%) own the houses/flat they live in.

The majority of surveyed households (77%) do not have a garden in their houses. Moreover, about 83% of the sample has a monthly income less than 2,000 NIS.

Based on the analysis undertaken, it was found that satisfaction with the provided service was found to be associated with the source of water (Fig. 1). About 85.3% of people who depend on private or shared water wells were found to be satisfied with the water supply while only 50% of those who depend on the municipal water service were satisfied, as they receive enough quantities with enough pressure to reach their homes.

Furthermore, it was found that people's commitment to pay their water bills is attributed to several factors, including their satisfaction with the water quality/service, as well as their income level. About 48% of the surveyed households who are satisfied with the provided water service, and about 46% of those satisfied with the quality of water, are committed to pay the bill. Over a half of those who are not committed to pay their water bills earn less than 2,000 NIS per month. Noting that, 43% who were found not committed to pay their water bills were also not committed to paying bills for other services including electricity, internet and mobile services.

Households were surveyed on their willingness to use PWMs and the expected effects of using PWMs. Out of the total surveyed households who are unwilling to use PWMs, 85% say that the use of PWMs will increase their household's financial burden, while 90% fear that the inability to pay for credit will result in water disconnection. In addition, it was found that households who reported that they are unwilling to use PWMs also reported the following issues and/or concerns:

- are not satisfied with the water quality they receive and accordingly feel that they are not entitled for payment.
- have a monthly bill greater than 50 NIS/month.
- are currently not committed to paying their monthly bills.
- have low income and are accordingly very sensitive to change in bill amount.
- are not familiar with Prepaid meters and unaware of its functionalities.

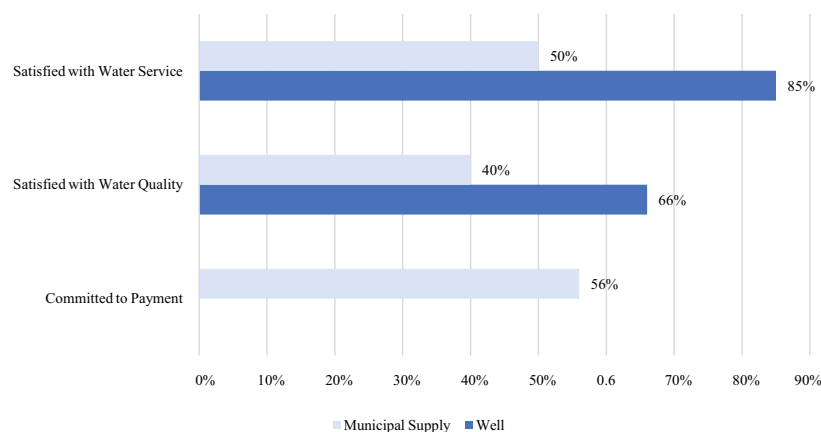


Fig. 1. Source of household domestic water vs. satisfaction with quality, satisfaction with service, and commitment to payment.

Fig. 2 illustrates the percentage of those who are unwilling to use PWMs that also reported these issues/concerns. Based on these findings, it can be presumed that people with the following characteristics are less sensitive (less unwilling) to use PWMs:

- are mostly employed with fixed income rate (75% of the surveyed households).
- are less affected by the factors above; satisfied with water quality received, committed to pay monthly bills, and/or are familiar with PWMs.
- Live in buildings with multi-tenants and share joint meters: most of the people who live in rented houses and in multi-story buildings, where water meters are shared, prefer to have separate PWMs installed for their houses (About 60% of the total surveyed households willing to use PWMs live in multi-story buildings or rented houses).

A key social concern highlighted during data collection and research is the issue of treatment of vulnerable groups and the poor with regards to the installation of prepaid meters, given the persistently high unemployment and poverty rates in the Gaza Strip.

Based on the socio-economic analysis, the following is recommended:

- Installation of prepaid water meters should target areas or customers who have sufficient and uninterrupted supply of water.
- For achieving significant results, it is recommended to start by considering the following target customers for installation of prepaid meters:
 - Large customers who are responsible for high consumption, such as commercial premises and facilities.
 - Customers, commercial and residential, with high accumulated debts.
 - Customers who are historically committed to paying their bills.
 - Customers whose income are above 2,000 NIS/month.
 - Customers who have joint meters and are suffering from unfair billing.
 - Customers who request prepaid water meters.
- Consider introducing incentive programs to encourage more people to use PWMs. This could include the following: discounts on and/or waiving of new subscriptions fees, discounts on water bills for a certain period, waiving costs of new meters and installation, discounts on arrears.
- Consider introducing public awareness campaigns on the use and benefits of prepaid water meters in reducing consumption levels and debts, as well as on procedures for non-payment.
- In early stages, it is recommended to avoid installation for customers who are considered poor or unprivileged; until social safeguards are in place, as these may have high resistance for prepaid water.
- If prepaid meters are to be implemented on a wide scale, safeguards for poor and unprivileged customers should be developed with the corresponding ministries (the PWA, the Ministry of Social Development (MoSD), etc.). Policy recommendations in this regard are provided in

the legal and governance section.

- Emergency plans for the provision of water in emergency situations regardless of the availability of credit in the customer's meter should be in place by the PWA and the service providers. This could be in the form of spare credits or a continuous supply of 15 l/c/d, as recommended by WHO for emergency conditions.

4.2. Legal and governance status

Opposition to prepaid water meters for residential customers has been vocalized by certain civil society organizations, particularly given the current political and economic context in Palestine. The opposition perceives prepayment as the “commodification of water,” and therefore this compromises the human right to water – as guaranteed under international law – by making access contingent on advance payment (Articles 11 and 12 of the 1966 International Covenant on Economic, Social and Cultural Rights). Moreover, they perceive it as a discriminatory practice that does not give considerations to the poor. Other organizations argue that this system is considered unjust only if it was obligatory. Therefore, they believe that the use of PWMs should be optional, and awareness should be raised to the public in this regard.

While many communities in the Palestinian territory perceive access to water as an inherent water right, the right in accordance with the Palestinian Water Law (Decree No. 14, 2014), defines “water as a service at specific prices,” and thus the service of water provision is not free of charge. This is also in line with the UN General Assembly (General Comment 15, 2002), which recognizes the right of every human to have access to sufficient water for personal and domestic use that is safe, acceptable and affordable, as well as physically accessible [17]. Payment for water services is therefore necessary to secure sustainable and reliable provision of water services, regardless of the payment method (post-paid or prepaid) or technology. Furthermore, the installation of prepaid water meters can be and should be motivated by a commitment to improving service delivery to all people, including poor customers, and that such technology can be a suitable option for meeting the service needs of the population rather than a commodification tool. Additionally, in the case of unlawful disconnection of water, the customer has the right to a hearing or urgent relief granted by the courts in accordance with Civil Procedure and the Palestinian Trade Law No. 2, 2001.

Thus, the Palestinian Authority has issued several governmental decisions encouraging the implementation of prepaid water meters and provided general guidelines to the respected authorities. The first introduction of the prepaid water metering concept in Palestine was in 2010, when the Palestinian Cabinet issued a decision (No. 13/51/03) authorizing their installation. This decision encouraged local water service providers to install prepaid water meters as a cost recovery measure. This was supported by subsequent decisions in 2010, 2013, 2014, 2017, 2018, and 2019 aiming to incentivize service providers in Palestine to install PWMs in the hope of enhancing cost recovery and improve collection rates at service provider

level and at bulk supplier level. At present however, there is no policy and regulatory framework that adequately sets out how the PWM system should be deployed, and how service providers are expected to work with customers in rolling out this technology. Some countries have identified a minimum quantity of water that is supplied to everyone free of charge in accordance with the minimum requirement set by the World Health Organization at the basic level of 20/l/d. To date, Palestinian laws and regulations have not identified a minimum quantity of water or safeguard programs to address specific utility services for the poor. While an existing social protection system is in place, which offers a monthly subsidy to the poor, this does not offer any conditions on how it should be spent.

To address concerns of provision of water to the poor and unprivileged people, the MoSD is looking into new approaches to support vulnerable populations in accessing basic services. While an existing, yet limited, social protection system is in place, the MoSD is working on improving this. Efforts are also being undertaken by various Palestinian institutions to subsidize water services and water debts; however, this is still a work in progress and has not been officially implemented.

To enable the implementation of PWMs at a wide-scale, different governance and legal frameworks need to be in place to ensure the effectiveness of their implementation and to ensure protection to local service providers and customers. Furthermore, how it is deployed must be managed by governments, regulators, and service providers by putting in place appropriate policy and regulatory frameworks and working closely with customers in rolling out the technology, as with any other technology. Recommendations include:

- Prepayment should not be implemented as a punitive measure for customers who do not pay, and safeguards should be available to reduce the potential for inconvenience or hardship to customers. Sound regulatory guidance could assist the service providers in identifying potential customers who may benefit from the technology, as well as developing guidance to ensure recourse options are made available. It is advised that international best practices, in this regard, are considered.
- Customers should be given the option of the payment technology for water service provision: prepaid or postpaid.
- PWA, in coordination with relevant stakeholders, should identify a minimum level of water as a basic humanitarian need, in accordance with international laws and best practices, to be supplied to all customers in cases of non-payment for an identified specific period.
- MoSD should develop policies and mechanisms to ensure the poor are protected through targeted subsidies/social safeguards. This should include a process of appeal for subsidies. This could be in the form of a distribution of charged credits for PWMs, arrangement between MoSD and the service providers to partially or fully subsidize the water bills of the poor and unprivileged.
- Procedures for punitive measures for non-payment and looting should be introduced and should be in line with the relevant legislations and social protection programs.
- Ensure plans for any possible water disconnection measure for non-payment for water can occur only after the

concerned water user has been notified, according to a predefined and communicated procedure, and given a hearing or the right to appeal in accordance to the Civil Procedure and the Palestinian Trade Law No. 2, 2001.

- PWA and ministry of local government should ensure that water service providers who will implement prepaid meters have the capacity to manage implementation and operations of prepaid meters.
- PWA, ministry of local government and ministry of finance should enforce separate water accounts from other municipal accounts.
- PWA should clarify and adopt measure for wastewater billing in case of prepaid water billing; a possible measure is through a mechanism to measure wastewater consumption based on water consumption.

4.3. Readiness of service providers

According to the interviewed water service providers in Gaza, a definite degree of improvement in collection and minimization of debts has been attributed to the implementation of PWM programs, which help in improving the provided services as a result. Service providers believe that prepaid meters can help eliminate challenges arising from reading conventional meters including human errors, inaccurate billing, high customers' water consumption, and managing water leaks and illegal connections.

The readiness of service providers in the Gaza Strip, however, does not comply with the requirements needed for the implementation of prepaid meters programs. Only two service providers in Gaza have some experience in implementing such programs, CMWU (in Rafah) and Beit Lahia (also with CMWU support), though this experience is still under investigation and piloting as set out above. Other service providers are currently planning to implement prepaid water meter pilots as a measure to manage and reduce non-revenue water, such as Khan Younis municipality. Currently, Khan Younis municipality is planning to implement a project towards the installation of prepaid meters in specific areas benefiting from the desalinated water in Khan Younis. Moreover, most service providers are lacking the adequate capacities to implement and manage these programs, including the lack of required equipment and well-equipped technical staff to engage effectively. Transferring the water and wastewater departments from the municipalities in Gaza to CMWU will enable the installation of PWM and make it much more feasible, as CMWU has the knowledge and the expertise to handle the installation and maintenance of the PWM.

The municipal water supply system in the Gaza Strip has been running at a deficit for years and municipalities run persisting financial deficits, showing that most are unable to cover their operation and maintenance costs. One of the interviewed municipalities, for example, indicated that they do not have the financial ability to pay meter readers to read meters regularly (monthly) and accurately. The interviewed service providers in Gaza stated that their main concern regarding the implementation of prepaid meters currently is that their deficit budget cannot afford the installation and maintenance of prepaid water meters and the associated software systems, as well as the training of their technical staffs

to deal with such systems. While the study did not conduct a financial audit of service providers, the consultations with service providers, supplemented by reports conducted by the World Bank in 2019 and the Water Sector Regulatory Council in 2018 illustrating low-cost recovery rates, indicate that the financial challenges faced by service providers may be a significant barrier to advancing PWM systems without external support.

Effective implementation of a prepayment system requires not just the new technology, but also an integrated management system, a well-resourced dedicated staff, and extensive preparation and consultations with customers to reorient their thinking. Therefore, along with relevant recommendations presented in other sections, the below are also highlighted for the rolling-out of prepaid meters for customers:

- A dedicated unit within the service provider's structure should be in place and equipped with the required skilled staff, equipment and capacity building programs
- Long-term service agreement with suppliers to ensure continuity of support.
- Charging stations for customers in different areas should be made available. Charging software should be constantly active.
- Monitoring activities should be carried out, followed by field investigations.
- Financial support could be obtained for deployment of PWMs; procurement and installation of devices and software, capacity building for service providers' technical staff, 2-y maintenance period including spare parts, and awareness campaigns.

4.4. Commercial and technical suitability of the prepaid technology for the Gaza market

Currently, limited types of prepaid meters are available in the West Bank, while no suppliers are available in Gaza, given that this technology is not widely implemented in Gaza; only a few distributors for one company are present. These dealers started working with prepaid meters when GEDCo started its installations of electricity prepaid meters in Gaza 10 y ago. Based on local experience, a two-year

warranty could be provided by the supplier. Extending the warranty period for over two years significantly increases the cost of the meters. Maintenance costs depend on the type of maintenance required. The supplier usually bears the cost during the warranty period, and the customer bears it afterwards. Main parts of the meter can only be provided through the supplier, while other common parts can be provided through the local market.

With regards to the import of meters into the Gaza Strip, which faces restrictions on the entry of materials considered 'dual-use' by Israel, CMWU's experience in importing 250 prepaid meters in 2018 showed that early coordination is required. The contractor was not able to provide the meters within the contract period due to delays in the coordination process within the Gaza Reconstruction Mechanism system. There are several types of prepaid meter devices and systems available in the world. Considerations of the water and environmental situation in the targeted country or area determines the type of meter to be selected for deployment. Specifically, for the case of the Gaza Strip, the below technical specifications should be considered:

- As grid electricity is not reliable, the battery of the meter is a major consideration. Prepaid meters' batteries have a life span of 3–5 years. Ease of procurement and replacement of batteries should be considered.
- Meter should support latest technologies and should not be outdated in less than 10 years.
- Meters should be set up for different tariff structures based on different customers and can enable billing based on different tariff blocks for the same customer. Moreover, the meter can be adjusted based on changes in tariff structures.
- Meter should be resistant to hot and cold weather as well as humidity.
- Meter device should support operating pressure of 16 bars and withstand low water quality in terms of sand content, total suspended solids, and the salinity/total dissolved salts, which reaches up to 3,000.
- Procured databases should be licensed and the software should be web-based with an internal Application Programming Interface to help organize different software systems if more than one system exists.

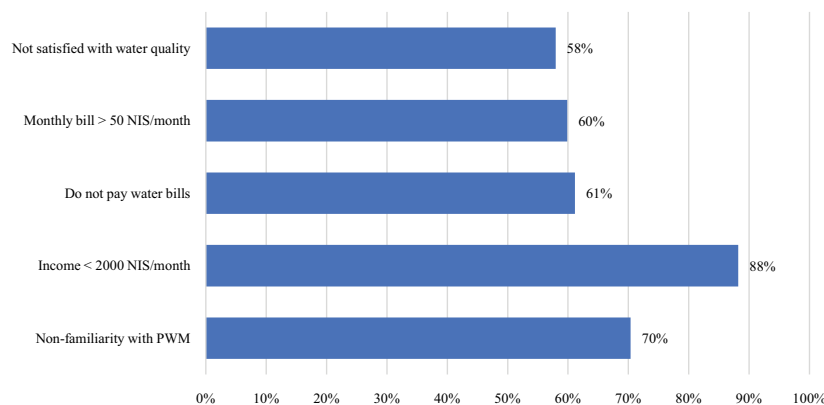


Fig. 2. Factors that could contribute to unwillingness to use PWMs.

- Service agreements with suppliers should be established to ensure continued support and maintenance.
- Testing of software as well as the metering devices should be possible.
- Spare parts should be available in Gaza.
- The prepaid metering software should be integrated to the service providers' accounting, billing, and any other systems.
- Charging and monitoring programs should have multiple technical capabilities for monitoring and data acquisition, where charging is done manually by smart cards and monitoring is performed remotely by radio frequency systems.
- Maintenance reports should be issued instantly to enable immediate response.
- There should be flexibility in setting up features and specific procedures, such as continued provision of service in case of emergency; running out of credit after certain hours or on weekends/public holidays; setting up different tariffs based on location/customer groups.
- Types of available prepaid water meter include multi jet dry type, volumetric type, and ultrasonic type. Multi jet dry and ultrasonic types of prepaid meters are recommended for use in Gaza as they support the specific technical requirements and support situations of intermittent supply and low quality of water; however, the Multi Jet Dry is more sensitive to low water quality, there for the Ultrasonic is choice number one for the prepaid water meter in Gaza. However, municipalities in the Gaza Strip use Multi Jet Dry meters as postpaid water meters. According to maintenance histories, these meters have spare parts which have low cost and can maintain low frequency rates for maintenance and repair. They are more robust against wear and tear from sand and gravel in the water than volumetric meters. As such, the multi jet type dry is the second choice for prepaid water meters in Gaza.

5. Conclusion

Based on the analysis undertaken of the results from household surveys, it is concluded that people's satisfaction with the water quality/service is a noteworthy driver for their commitment to pay their water bills, along with the income level. In addition, the analysis of the surveys revealed that the economic status of a household is a major factor affecting its willingness to use prepaid water billing. Various factors are also found to be associated with people's unwillingness to use PWM; these include their satisfaction with the water quality/service as well as their previous commitment for bills payment.

Among different social concerns regarding the implementation of PWMs, the main concern identified during the data collection and analysis stage was the issue of treatment of vulnerable groups and the poor with regards to the installation of prepaid meters, where different measures should be considered to ensure these group's suitable access to water in light of national and international laws and regulations.

Technically, the results showed that based on the comparison of the performance of different types of PWMs

considering the characteristics of municipal water supply in Gaza, the Ultrasonic type is the most recommended PWM, and the Multi Jet Dry type is the second most recommended PWM to be used in the Gaza Strip. The Ultrasonic type is the most effective under conditions of intermittent water supply and low quality of water, while the Multi Jet Dry type is slightly more affected by these conditions but relatively suitable.

The findings also revealed that due to the lack of adequate financial and human resources capacities to implement and manage such programs among the service providers in the Gaza Strip, not all service providers in the Gaza Strip can comply with the technical and/or financial requirements needed for the successful implementation of prepaid meters programs, given that only two out of 25 service providers in Gaza have some experience in implementing such programs. While the study did not conduct a financial audit of service providers, the consultations with stakeholders, supplemented by previous studies indicating low cost recovery rates, suggest that the financial challenges faced by service providers may be a significant barrier to advancing PWM systems without external support.

This study has concluded that effective implementation of a prepayment system in the Gaza Strip requires an integrated management system that takes into consideration the various social, technical, legal and commercial aspects identified in this analysis. To ensure this, different actions were recommended to be implemented.

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References

- [1] The United Nations Office for the Coordination of Humanitarian Affairs (OCHA), The Monthly Humanitarian Bulletin | October 2018: Study Warns Water Sanitation Crisis in Gaza May Cause Disease Outbreak and Possible Epidemic, 2018, New York, United States. Available at: <https://www.ochaopt.org/content/study-warns-water-sanitation-crisis-gaza-may-cause-disease-outbreak-and-possible-epidemic>
- [2] Palestinian Water Authority (PWA), Rolling Program of Interventions, Semi Annual Progress Report, 2019, Gaza, Palestine.
- [3] Water Sector Regulatory Council (WSRC), The Performance of Water and Wastewater Service Providers in Palestine, Summary Report for 2016–2017, 2018, Ramallah, Palestine.
- [4] Palestinian Water Authority (PWA), Gaza Water Security Mapping Project: Final Report, 2019, Gaza, Palestine.
- [5] World Bank, Securing Water for Development in West Bank and Gaza, 2018, World Bank, Washington, D.C.
- [6] R. Hanjahanja, C. Omuto, Do prepaid water meters improve the quality of water service delivery? The case of Nakuru, Kenya, *Smart Water*, 3 (2018), doi: 10.1186/s40713-018-0010-9.
- [7] I.G. Nurhayata, I.W. Sutaya, K.U. Ariawan, The development of prepaid water meters based on AT89S52 Microcontroller, *J. Phys. Conf. Ser.*, 1810 (2021) 012004.
- [8] M. Thulsidas, Five Things You Need to Know About Prepaid Water. The Business Technology Media Company, Johannesburg, South Africa, 2019. Available at: <https://www.itweb.co.za/content/KBpdgvpPKY2vLEew>
- [9] S. Vermaak, Are Prepaid Systems the Solution to Sustainable Water Management? The Business Technology Media Company,

- Johannesburg, South Africa, 2018. Available at: <https://www.itweb.co.za/content/dgp45vaGWPdMX918>
- [10] C. Heymans, K. Eales, R. Franceys, *The Limits and Possibilities of Prepaid Water in Urban Africa: Lessons from the Field*, International Bank for Reconstruction and Development/The World Bank, Washington, D.C., 2014.
- [11] United Nations Development Programme-UNDP, *Detecting Non-Revenue Water Using Internet of Things and Artificial Intelligence*, (2020). Available at: <https://www.ps.undp.org/content/papp/en/home/blogs/detecting-non-revenue-water-using-internet-of-things-and-artific.html>
- [12] T.R. Gambe, *Prospects of prepaid smart water metering in Harare, Zimbabwe*, *Afr. J. Sci. Technol. Innov. Dev.*, 7 (2015) 236–246.
- [13] A.G. Nhema, T. Zinyama, *Prepaid water meters in Zimbabwe: the quest for an efficient water delivery and cost recovery system*, *Global Business Econ. Res. J.*, 5 (2016) 1–30.
- [14] Palestinian Water Authority-PWA, *The PWA's Plan Includes Three STLVs, Three Wastewater Treatment Plants, The GCDP, and The Associated Works Program, Data on Operational Costs are Sourced From the OQ and PWA O&M Analysis*, 2019.
- [15] PCBS, *Poverty Profile in Palestine, Ramallah, Palestine*, 2017.
- [16] PCBS, *Preliminary Census Results, PHC 2017, Ramallah, Palestine*, 2018.
- [17] UN Office of the High Commissioner for Human Rights-OHCHR, *Fact Sheet No. 35, The Right to Water*, 2010. Available at: <https://www.refworld.org/docid/4ca45fed2.html>