March - April 2020
ISSN: 0193-4120 Page No. 4768 - 4775

Benchmarking of the Water Supply and Wastewater Management System of a Smart City: A Case Study of Cauayan City, Philippines

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Abstract

Undeniably water supply is one of the basic services for demographic, social and economic development of a society. Thereby, the need to have access to reliable and excellent quality water supply regardless of uses is deemed necessary.

The study aim was to benchmark the performance in terms of water supply and wastewater management aspects of the Local Water Utility (LWU) system. The performance evaluation was based on the following domains –(a) sustainability of water supply; (b) water users satisfaction; (c) waste management practices; and (d) compliance of the local government unit in accordance to water security and management.

The assessment framework and indicators used were adapted from the established benchmarking manual by the International Water Association (IWA). The method used in collecting information and/or data for this study involves focused group discussions, key informant interview and conduct of field survey wherein a total of 388 respondents were selected employing stratified random sampling.

Results showed that in terms of water sustainability based on a 40-year projection, in 2040 and 2050, system groundwater withdrawals would exceeds the allowable or safe groundwater yield. Overall acceptability on water quality was slightly poor with a rating of 54% wherein 55%, 56%, 59% and 50% acceptability rating were attributed by taste, odor, color and pressure, respectively. Meanwhile, lack of waste water treatment facilities were observed which resulted to direct disposal of wastes to water bodies. For the last study domain, the local government passed four (4) city ordinances or enabling laws on water and wastewater management for sustainable water resources utilization.

In light of the results of this benchmarking study, more specifically on the issue of sustainability, it is highly suggested that providing or developing alternative water source is necessary as a sustainable approach to adequately and reliably supply water demand for the future generations.

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I. INTRODUCTION

Providing reliable and affordable wastewater treatment in rural and urban areas is a challenge, particularly for developing countries (Massoud, Tarhini and Nasr, 2009). Whereas a centralized wastewater collection and treatment system is costly to build and operate, decentralized approach for wastewater treatment can be used as an alternative. These employ a combination of onsite and/or cluster systems which can become more reliable and cost-

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effective. Additionally, a decentralized approach in wastewater management may offer opportunities for wastewater re-use and resource recovery, which may improve local environmental health conditions (Parkinson and Tayler, 2003). It may also offer increased opportunities for local stakeholder participations in planning and decision-making.

Goal 6 of the 16 Sustainable Development Goals (SDGs) set out by the United Nations 2030 Agenda and SDGs involve the need for Clean Water and Sanitation (El-Maghrabi et al, 2018). The scarcity and poor quality of water, and inadequate sanitation across the world, could negatively impact food security, livelihood, and educational opportunities of poor families (Goal 6, n.d.). Currently, more than 2 billion people, particularly in several developing countries within the Sub-Saharan Africa, Central Asia, Southern Asia, Eastern Asia and South-Eastern Asia, are living with the risk of low access to freshwater resources. Thus, the target of Goal 6 by 2030 is to achieve universal and equitable access to safe and affordable drinking water for all. To do so, a target was also to improve water quality by reducing pollution, eliminating and reducing dumping and releasing of hazardous wastes to the environment. Another target of Goal 6 was to implement integrated water resources management at all levels by 2030. In addition to being helpful for the environment, achieving Goal 6 could also achieve Goal 3 of the SGDs: Good health and well-being (Goal 3, n.d.). Kajee et al in their paper, argued that there could be considerable benefit in approaching and implementing together two seemingly separate goals: the SGDs and the Developmental Origins of Health and Disease (DOHaD) (Kajee et al, 2017). Here, the DOHaD demonstrates that early exposures to environmental hazards (e.g. wastes, unsanitary water) could not only affect future health, but also that of future generations.

Isabela is the second largest province in the Philippines and the largest in the island of Luzon. Primarily an agricultural province, its main produce are rice and corn. In 2012, Isabela was declared as the country's top producer of corn with 1,209,524 metric tons (Department of Agriculture, 2013). Furthermore, it is the 10th richest province of 2011 (Inquirer PH, 2014). Isabela has four trade centers in the cities of Ilagan, Cauayan, Santiago and the municipality of Roxas. Cauayan city is a 3rd class city in Isabela, with total population of 140,218 people (Philippine Statistics Authority, 2016) and the 4th largest in population size among the municipalities of Region 2 with 30,556 number of total household (2016) and with 9,844 potable water connections. Politically, it is subdivided into 65 barangays over a total land area of 336,40 km2 (National Statistical Coordination Board, 2014) including 9,959,7065 hectares for Agricultural lands. Cauayan City as Smart City, recognized by the Department of Science and Technology (DOST) for its innovation in adopting science and technology development programs such includes the integration of the information and communications technology(ICT) in Cauayan City Connect, website for e-commerce, barangay website, e-Gaps and the Dost Juan time -all geared toward an interactive and efficient city operation and services, thus contributing to the attainment of Goal 11 (Sustainable Cities and Communities). Identified under the RPFP 2001-2030as one of the region's key urban centers and to host the Proposed Isabela Special Economic Zone and the Regional Agro-Industrial Growth Center. In terms of its commerce and trade, over 2,422 commercial establishments are established in the city .These commercial establishments operate in Agriculture, Banking and Finance, Commerce industries, providing a diverse range of facilities to cater to the administrative, social commercial and institutional requirements of the region's population.

Here, the water supply and wastewater management systems of Cauayan City, Philippines, was assessed in the context of Smart Cities and Goal 6 of the 16 SDGs. Specifically, factors such as service area

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March - April 2020
ISSN: 0193-4120 Page No. 4768 - 4775

coverage, system facilities and population and demand projections of the existing water management systems were used to assess system sustainability. Additionally, the impact of the existing water management system on the social context was also determined by measuring consumer satisfaction. Using these data, policies for better governance were proposed to the local government unit (LGU) of Cauayan City.

II. METHODOLOGY

Part of the methodology is the stakeholder consultations with governments, civil society organisations, development cooperation agencies, the private sector, and other business sector were consolidation of issues and problems were identified including good practices across all levels and sectors of society. Another is the conduct of key informant interview and field interview with household and concessionaire and focus group discussion is also administered. The study uses the GIS (geographic Information System) for mapping important areas that highlights the location of the respondents and the reservoir, pumping stations and water system coverage. There were about 388 respondents selected through stratified random sampling.

Stakeholder's Consultation and Focus group discussion

III. RESULTS AND DISCUSSION

Water Management Sustainability of Cauayan City, Philippines

Water Production

The combined daily average water production capacity of the Cauayan City Water District (CCWD) is 10,518.13 m^3 which is sufficient amount for 24-hour water supply for 12,067 concessionaires. From the total daily pumped water, only 9,229.63 m3 is metered and accounted for, resulting in total water loss of 1,288.50 m3 (distribution efficiency = 87%). This unaccounted water losses could potentially supply an additional 2,863 households (one community/barangay) when optimally used and/or regulated.

Service Area Coverage

The CCWD served 15 out of the 52 barangays of the city corresponding to 29.67% service area coverage. To put into social context, this accounts for only 9,085 households served from the total household of 30,623, wherein majority is within the city proper and adjacent barangays as shown in Figure 1.

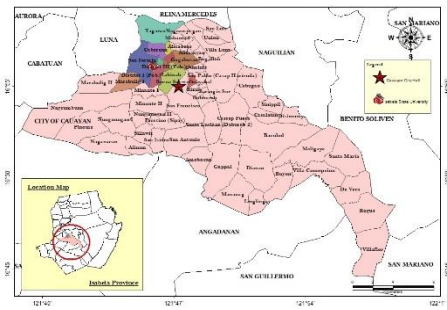

Figure 1. Cauayan City Water District service coverage

In terms of number of connections, there are 12,067 existing or active concessionaires with 9,085 are classified as residential, 98 are government offices, 1,834 are commercial establishments, 24 are bulk, and 16 are unbilled.

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March - April 2020
ISSN: 0193-4120 Page No. 4768 - 4775

Water System Facilities

The CCWD has a total of 15 pumping stations (Figure 2) to support water demand of the 12,067 concessionaires with a total volume requirement of 9,229.63 m3 per day.

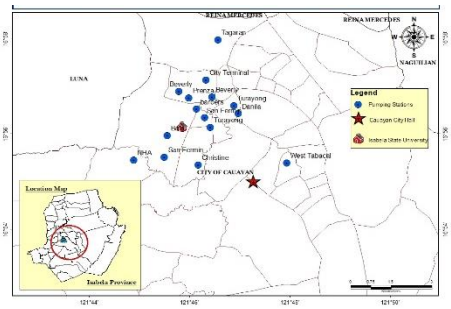

Figure 2. Cauayan City Water District pumping and storage reservoir locations

The capacity of the different pumps is reflected in Table 1 where pump No. 5 has the highest pumping capacity while pump no. 7 is the least with equivalent pump discharge capacities of 31.57 and 5.15 li per second, respectively. The combined discharges of these pumps were sufficient to supply the daily water demand of all concessionaires.

Table 1. CCWD pump locations and discharge capacity

WELL NUMBER	PUMP CAPACITY, li sec^{-1}
Turayong, Pump No. 1	6.69
San Fermin, Pump No. 2	9.61
Turayong, Pump No. 3	6.76
San Fermin, Pump No. 4	17.77
Danila, Pump No. 5	31.57
Bala, Pump No. 6	19.65
Tagaran, Pump No. 7	5.15
City Terminal, Pump No. 8	7.01
Christine, Pump No. 9	19.09
Barbers, Pump No. 10	22.55
Prenza, Pump No. 11	25.56
Beverly, Pump No. 12	5.30
Beverly, Pump No. 13	5.33
West Tabaccal, Pump No. 14	12.03
NHA, Pump No. 15	18.92

To address the continuous water demand, eight (8) elevated water storage tanks/ reservoirs were strategically installed within the service area as also shown in Figure 2. In addition to the pumping stations and tanks, two (2) water filtration facilities were also constructed at Barangay Tabacal and Centro to address water quality issues and concerns.

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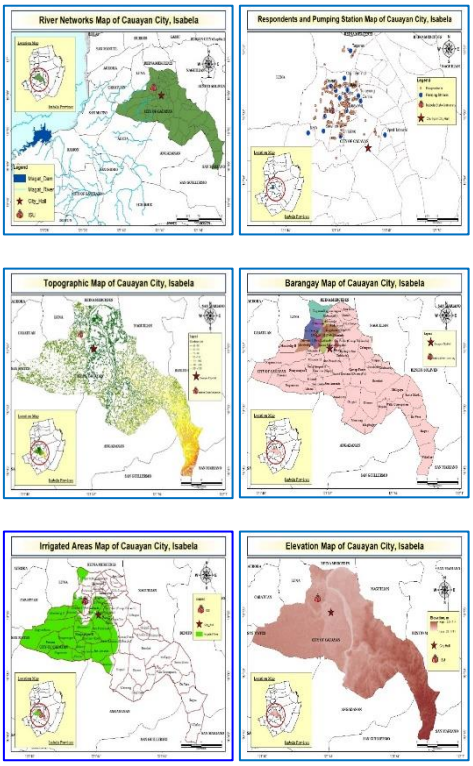

Water Usage per Capita

Domestic water usage under CCWD was estimated to be 89.32 L/capita/day considering an average family size of 5 members. This estimate was below the average consumption of 120 L/capita/day in urban settings based on the estimates conducted in major cities of the Philippines by the World Bank in 2003. The estimated water usage for CCWD concessionaires constitutes: drinking water for survival, water for human hygiene, water for sanitation services, and modest household needs for preparing food.

The above per capita estimates conforms to the basic water requirement of 50.00 liter per person per day as proposed by Gleick, 1996 which excludes water for laundry activities. The result suggest that CCWD concessionaires still consumes water at an acceptable state.

Population and Water Demand Projections

Table 2 shows the projected household population of the City of Cauayan and the future water demand from the baseline year of 2019. Population projections and industry growth were based on the latest growth rate report of the Philippine Statistics Authority (PSA, 2017) of 1.5% and 6.7, respectively. While future water demand were based on the combined average water usage by domestic, commercial and/or industrial sectors.

Table 2. Population and Water Demand Projections

Year	Population Projection		Water Demand Projection		Required Groundwater Abstraction rate, li sec^{-1}
	Household	Industry/ Commercial	Household , m^3 day^{-1}	Industry/ Commercial, m^3 day^{-1}	
2020	31,079	2,079	13,880.13	24,120	439.82
2030	35,700	3,978	15,943.52	46,134	718.49
2040	40,320	7,608	18,006.91	88,240	1,229.71
2050	44,940	14,551	20,070.31	168,776	2,185.72

Considering the future population for the next 30 years, water demand would also sky rocket with an equivalent percent increase of 63.36%, 179.60%, and 396.96% for 2030, 2040 and 2050, respectively, based on the present demand as of 2019. These results are noteworthy to consider that agricultural demands or groundwater withdrawal for agricultural purposes and individual domestic wells within the City of Cauayan are not included in the analysis. Thereby, with the projections in 2040 in groundwater withdrawals might already exceeds the allowable or safe groundwater yield of 2,000 li per second (NWRC and NHRC, 1983). Also, more noteworthy to consider the projected abstraction in the year 2050 reached as high as 2,185.72 li per second which is way above the safe yield. These results suggests that mining yield would have been reached within this timeframe given the above projection estimates.

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ISSN: 0193-4120 Page No. 4768 - 4775

The aforementioned results suggest that another water source (e.g. surface water) for domestic use should be considered to sustainably consider demand and environmental requirements. This is besides that Cagayan valley region is blessed with abundant fresh water resources, over-groundwater extraction or groundwater mining could still pose a threat to this valuable groundwater resource.

Assessment of water user's satisfaction

The scarcity and poor quality of water, and inadequate sanitation across the world, could negatively impact food security, livelihood, and educational opportunities of poor families. Thus, the target of Goal 6 by 2030 is to achieve universal and equitable access to safe and affordable drinking water for all. In Cauayan City, Isabela, the población area is served by the Cauayan City Water District (Level III utility provider), which provides safe Centralized Water System. Additionally, housing subdivisions have their own water supply system (Level I-III). In this study, Surveys were conducted on selected households and commercial establishments around Cauayan city to determine the consumer's perception and acceptability of the water utility service they are getting from NAWASA. At least half of the connected households deemed the water supply to have an acceptable quality (54%), taste (55%), odor (56%), color (59%) and pressure (50%). This entails that the quality, physicochemical characteristics (taste, odor, and color) and availability (i.e. water pressure) of the water utility service were sufficient and acceptable to the household consumers. In contrast, only less than half of the surveyed households that were not connected to the utility service were satisfied with the water's quality (35%), taste (25%), odor (33%), color (38%), and pressure (38%). Considering that these households derive their water from groundwater, the overall quality and quantity will be substandard compared to quality-treated water provided for by a utility service. For the connected commercial establishments, less than half were also satisfied with the utility service's water quality (44%), taste (48%), odor (37%), color (37%), and pressure (33%). Commercial establishments are expected to require higher influx of water to accommodate the customers, as compared to household establishments which cater only a few people at a time. Thus, commercial establishments have stricter requirement for their water quality and quantity service needs but nonetheless can be met by upgrading the facilities at of the water utility service.

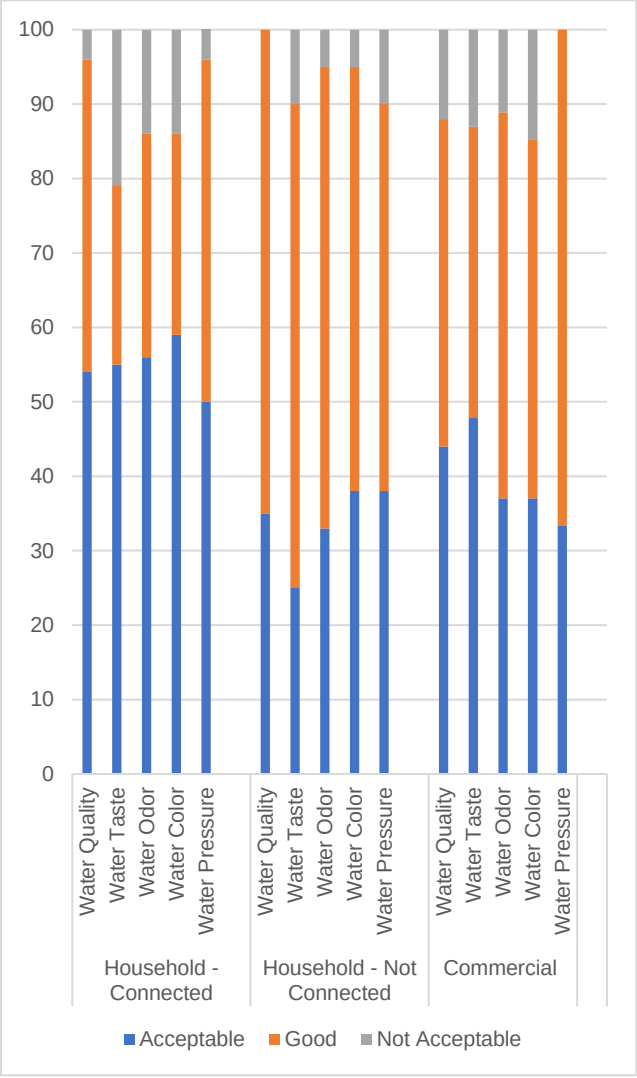

Figure 3. Satisfaction of the respondents in the City of Cauayan, Isabela

3. Enabling policies/ordinances of the local government unit in accordance to water security and waste management

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Based on these assessments of water management system in Cauayan City, the researchers found several aspects of the system that could be improved upon based on international standard; specifically, based on the European Benchmarking Co-operation (EBC) on Water & Wastewater Benchmark (EBC, 2018). Specifically, the EBC performed assessment of water services using indicators in five performance areas: water quality, reliability and service coverage, service quality, sustainability and finance & efficiency. Thus, the researchers compared the data obtained from the current study against the standards set by the EBC (2018). In the performance areas of reliability and service coverage, the water management system of Cauayan City fell behind in terms of Reliability and Service Coverage (with a service coverage of only 29.67%) and Water distribution efficiency (with an average daily loss of 1,288.50 m3/day). In terms of Service Quality, although official complaints were not recorded by the water service, the survey results show that the at least 40% of the consumers (n=12,067 total concessionaires) were not satisfied with the water quality, taste, odor, color and pressure. In terms of complaints per 1000 properties, this value is equivalent to approximately 400 complaints/1000 properties, which is well above the median value of the EBC 2018 report of 0.75 complaints/1000 properties (EBC, 2018). In terms of Sustainability, population and water demand projections of Cauayan City after 30 years show that the current system may not be sufficient; thus, another water source for domestic use should be considered to sustain consumer demand.

In order to facilitate these improvements in Cauayan City water service, local government unit (LGU) policies on water management could be supplemented. Currently, two city ordinances relating to water services in Cauayan City are in effect: Ordinance No. 2009-005 ("Ordinance Prescribing Penalties to any Person and Corporate Entities Indiscriminately Throwing and Dumping of Garbage and Dead Animals Along River Banks, Creeks and Bodies of Water within the Territorial Jurisdiction of the City of Cauayan, Isabela") and Ordinance No. 2016-082 ("An Ordinance Establishing Water Conservation Programs in the City of Cauayan"). However, these LGU policies pertain to aqueous environmental cleanliness (Ordinance No. 2009-005) or water conservation (Ordinance No. 2016-082). Although necessarily important ordinances in their own right, a specific LGU policy regarding the establishment of water service quality assurance and control systems adapting the EBC benchmarking standards should be put forth. Specifically, these LGU policies should address the deficiencies of the existing water service system in Cauayan City and likewise devise measures to supplement these deficiencies.

CONCLUSIONS AND RECOMMENDATIONS

Based on the data gathered in this study, it can be seen that the Water Supply System of Cauayan City, Philippines, requires further improvements for it to be sustainable and efficient in providing high quality and reliable water to the citizens of the Smart City. To facilitate such improvements, policies must be set forth by the city's Local Government Unit that provides a platform for improvement, all in accordance to International Standards for water systems. As such, the researchers suggest writing of a City Ordinance that adapts the European Benchmarking Co-operation (EBC) water benchmarking standards, with fund allocations for increasing water distribution efficiency, higher coverage area, and increased water quality assessment.

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