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Input-Throughput-Output Analysis of Water Resources in Sorsogon City, Philippines

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Abstract

Water is vital in sustaining life and will become increasingly critical in the long run, considering the constant population growth and economic development of a city. The study aimed to measure the input, throughput, and output of Sorsogon City along water and sanitation. Water and sanitation data were obtained from Sorsogon City Mayor's office and Sorsogon City Water District (SCWD) office. Data were also gathered through key informant interviews with SCWD personnel, city health officer, public health nurse, sanitary inspector, community environmental and natural resources officers, and wastewater treatment facility staff, and focus group discussions with eight barangay captains of barangays not served by SCWD and nine members of Barangay Water and Sanitation Associations. An input-throughput-output analysis on water resources was done. SCWD and non-SCWD have annual production volume of 3,292,566 m^3/annum and 2,017,920 m^3/annum, respectively. SCWD's billed volume was 2,370,648 m^3/annum: (domestic: 1,927,573; commercial/industrial: 301,879; institutional: 141,196) while non-SCWD domestic was 597,547.63 m^3/annum. Wastewater from household, commercial/industrial, and institutional plumbing were 2,525,120.63, 1,227.203, and 141,196 m^3/annum, respectively. The wet market and slaughterhouse wastewater treatment facilities treated 32,850 and 4,136.05 m^3/annum of wastewater respectively. Total input was 5,310,486 m^3/annum while the combined utilization and output was 6,861,715.26 m^3/annum. Their difference was 1,551,229.26 m^3/annum, which can be attributed to run-offs and leakages from pipes and connections. The input is not equal to the sum of the throughput and output of water and sanitation in Sorsogon City; hence, the city has not efficiently managed its water and sanitation resources as evidenced by partial coverage of SCWD, high system losses, absence of centralized sewerage system, and inadequate waste water treatment facility. It is therefore recommended that the city's water management system must be periodically upgraded to minimize system losses.

Keywords: *Urban, Metabolism Framework, Material Flow, Waste Water, Water District*

Introduction

There is a rising demand for water for domestic, agricultural and industrial purposes in the face of water shortage, inadequate facilities, and limited access to water, and environmental degradation and pollution. The access to and availability of water has become one of the most crucial problems confronting countries today, and managing their water resource has become a top priority in countries where water scarcity is threatening their progress (Environmental Science, 2009).

Most countries in Southeast Asia including the Philippines face a similar problem of water shortage due to decades of water misuse, destruction of tropical rainforest especially catchment areas, severe water pollution, excessive extraction of groundwater, and poor and unregulated land resource management. Given the many agencies involved in water management and with overlapping functions, institutional arrangements have to be streamlined, with proper delineation of roles and responsibilities. Policies and programs are also needed to be set in place for the regulation of use and extraction, including proper allocation among various users, pollution reduction to mitigate contamination of surface water and groundwater, water tariff restructuring and application of market-based instruments (such as user fees) to reflect the full value of water as a resource, and regular monitoring of surface water and groundwater quality and quantity (Partnerships in Environmental Management for the Seas of East Asia [PEMSEA], n.d.).

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Assessing for the water resources will determine the areas where depletion occurs, as well as the sources having degradation of water quality. In the aftermath of the El Niño phenomenon, the National Statistical Coordination Board (NSCB) has come up with estimates of the country's water resources through environmental accounting, using the Philippine System of Integrated Economic and Environmental Accounts (PSEEA), which is based on the United Nations System of Integrated Economic and Environmental Accounts (UNSEEA) framework. Initial estimates have shown that the total groundwater demand or withdrawal throughout the country grew from 4.3 billion cubic meters (bcm) in 1988 to 5.8 bcm in 1994 with an average annual increase of 5.3%. The groundwater demand covered the domestic, industrial, and commercial consumption of water. The water demand for agricultural sector was not part of the estimation due to data limitations. On the other hand, recharge, or the replenishment of the country's water resources through rain and other forms of precipitation, decreased from 1.9 bcm in 1988 to 1.5 bcm in 1994 with an average annual rate of 3.7% (Philippine Statistics Authority [PSA], 2016). Moreover, because of its location, groundwater can hardly be recharged (or not at all), once it gets depleted. Thus, sustainability of this resource depends on efficient management so that the existing water supply will not be withdrawn above the replenishment levels.

In June 2012 at the Rio+20 global summit on sustainable development, United Nations Environment Programme (UNEP) spearheaded the launching of the Global Initiative for Resource Efficient Cities (GI-REC) to bank on the potential for cities to institute action towards better resource efficiency (Sustainable Development Goals Knowledge Platform, n.d.). The GI-REC builds on existing city networks, and having a sustainable production and consumption access point to support cities with realizing the socio-economic, and environmental gains of resource efficiency. It attempts to study the flow of resources of individual cities around the world. The global initiative presents a mechanism for local government unit (LGU) officials to compare and share experiences and best practices and establish a peer-review process across cities so as to further improve access to resources and their efficient use.

One of the pilot cities is Sorsogon City, a relatively young city—created in 2000—located in the Bicol Region (Region V), Philippines. According to the latest census done in 2015, it had a population of 168,110, a population density of 610, and an annual population growth rate of 1.54. In 2015, the city had a gross domestic product (GDP) of Php6.22 million, which was equivalent to 0.05 percent of the Philippine GDP. It is a tropical coastal city that can be reached by sea and land. No commercial flights are available.

Material Flow Analysis (MFA) is now widely used at the national scale (Weisz *et al*. 2006), although it is not extensively used in developing countries. Although MFA has proven to be useful on a national scale, analyses focused on smaller areas are necessary to gain a better understanding of what material consumption is and how it can be controlled and reduced. Hence, a detailed analysis of domestic material consumption (DMC), with particular emphasis on water and sanitation (waste water disposal), is presented.

The objective of the study was to determine Sorsogon city's efficiency in water and sanitation resource flows. Specifically, it attempted to measure the amount of water locally extracted from water sources (input), the amount of water utilized (throughput), and the amount of waste water generated as a result of water extraction, distribution and utilization as well as wastewater management (output) of Sorsogon City.

Materials and Methods

Secondary Data and Documents

Documents containing water and sanitation data were obtained from Sorsogon City Health Office as approved by the city mayor. Likewise, letters requesting for access to data from Sorsogon City Water District (SCWD) office and Decentralized Wastewater Systems (DEWATS) wet market office were signed by the mayor to help the researcher obtain pertinent information about water and sanitation. The team identified the GIREC indicators where no secondary data were available and recommended possible information sources.

Respondents and Data Gathering Methods

Six key informant interviews (KIIs) were conducted among the personnel of the City

Health Office such as the City Health Officer, public health nurse, and sanitary inspector, as well as two representatives from the SCWD and DEWATS wet market personnel as interviewees to gather data not obtained during the initial data gathering session. It was discovered during the initial data gathering that only half of the city's barangays are serviced by the SCWD. Thus, the documents from the water district are not enough to provide a complete picture of the water access in the city. It became necessary to conduct a focus group discussion (FGD) with eight barangay captains of the unserved villages and nine members of Barangay Water and Sanitation Associations (BAWASAs) who went to the city hall upon the invitation of the mayor.

Data Analysis

The analysis resource flows are based on the determination of the main inputs and outputs for the system under consideration and does not require a description of the material circulation within the system. Specifically, the input-output analysis of water and sanitation using a simplified version of Barle's (2009) method, which states that the inputs should be equal to the sum of the utilization and outputs.

Results and Discussion

Input

SCWD Annual Production Volume. The major service provider for potable water is the Sorsogon City Water District (SCWD), in partnership with Abejo Waters Inc. It is a Level 3 facility that extracts water from 13 deep wells and four springs, with surface water reserves of 174,837 m^3. Of the city's 64 barangays, only 32 are being served by the SCWD. The other half are serviced either by village—and city government—managed facilities, or other facilities using various sources like wells, springs and water refilling stations. The City Environment and Natural Resources Office (CENRO) has no data on the surface water reserves of the 32 villages not covered by the SCWD. The SCWD's annual production volume is 3,292,566 m^3, while the non-SCWD's calculated annual production is 2,017,920 m^3.

Although half of the city's barangays are not connected to the SCWD, most of its population is covered. This is so because the areas it serves are the highly populated ones. In fact, only one-fifth of the population or around 33,600 individuals do not enjoy the SCWD's services. The SCWD's production volume for the next 10 years is sufficient to meet the needs of the growing population.

The SCWD is a government-owned and -controlled corporation created under Presidential Decree No. 198 or the Provincial Water Utilities Act of 1978. It was established in February 14, 1975, after it was issued a Conditional Certificate of Conformance by the Local Water Utilities Administration and has since then provided the water supply of the municipality and later the city of Sorsogon with the merging of the municipalities of Sorsogon and Bacon in 2001. In 2014, SCWD partnered with Abejo Waters Inc. to set up a bulk water supply facility tapping the Cawayan River as source because of its enormous volume of water seepage. The plan of the water district is to tap 50 liters per second out of the seepage of water from the river to adequately supply the needs of new customers in the

Table 1. Annual Water Extraction, Utilization, and Waste Water Generation of Sorsogon City

Inputs (Local Extraction)	Utilization (Material Throughput)	Outputs (To Nature)

• SCWD's annual production volume is 3,292,566 m^3
• The calculated annual production volume from sources other than the SCWD is 2,017,920 m^3
	• SCWD's annual billed volume is 2,370,648 m^3 broken down as follows:
	  ○ Domestic - 1,927,573 m^3
	  ○ Commercial and industrial - 301,879 m^3
	  ○ Institutional - 141,196 m^3
	• Non-SCWD domestic – 597,547.63 m^3
	• Loss – 29.73%
		• Wastewater from household plumbing is 1,927,573 m^3/annum
		• Wastewater from commercial and industrial plumbing is 301,879 m^3/annum
		• Wastewater from institutional plumbing is 141,196 m^3/annum
		• Non-SCWD domestic – 597,547.63
		• The wet market DEWATS wastewater treatment facility collects and treats 32,850 m^3/annum of wastewater
		• The slaughterhouse waste water facility collects and treats 4,136.05 m^3/annum

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western part of the city.

Estimates of water usage in Metro Manila by sources of water and quality of water service show that daily per capita consumption ranges from a low of 20 liters up to a high of 400 liters (Inocencio *et al.*, 1999). It appears that the per capital of water use in Sorsogon City falls within metro manila's range 20–400 liters though the latter is more urbanized than the former. Philippine Statistic Authority (2019) classifies water use as the sum of water use within the economy and water use from the environment. PSA defined water use within the economy as water intake for production and consumption activities, which is distributed by industries or households and by the Rest of the World (Imports) and for the following purposes: domestic, municipal, irrigation, power generation, livestock raising, fisheries, recreational, and other uses. It also describes water use from the environment as water abstracted from water resources, seas and oceans, and precipitation collected by industries and households for production and consumption activities, including rainfed agriculture (PSA, 2019).

Sorsogon City currently draws water from one river, 13 deep wells, and four springs, which serve 64 barangays from the districts of Bacon and Sorsogon. As of December 2014, there were 13,402 existing service connections and a total of 10,619 active service connections that were 100 percent metered. Of this total, 9,701 were residential and government connections, while 918 were commercial establishments.

Generally, water is classified into two types: surface water and groundwater. Groundwater is located underground in large aquifers and must be pumped out of the ground after drilling a deep well while surface water is found in lakes, rivers and streams and is drawn into the public water supply by an intake. Surface water is exposed to many different contaminants, such as animal wastes, pesticides, insecticides, industrial wastes, algae and many other organic materials while groundwater commonly contains less contamination than surface water because the rock tends to act as a filter to remove some contaminants (Goulds Water Technology, n.d.).

According to the SCWD, its surface water reserves is 174,837 m^3. However, this figure does not show the surface water reserve of the whole city because only 50 percent of the city's barangays are serviced by the water district. The City Environment and Natural Resources Office (CENRO) does not have data on the surface water reserves of the 32 barangays not covered by the SCWD. Thus, it is not possible to compute for the surface water reserves per capita within the city boundaries (Philippine Environmental Monitor, 2003).

The city's surface-water resources—the water in the city's rivers, streams, creeks, lakes, wetlands, and reservoirs—are vitally important to its people's lives. The main uses of surface water include drinking water, other public uses, and agricultural (irrigation) uses. Because surface waters are on the land surface, they are easily developed for use (Water Education Foundation, n.d.).

With the rapid population growth, urbanization, and industrialization, the quality of surface water and groundwater is reduced, especially in densely populated places and areas of industrial and agricultural activities. The disposal of household and industrial wastewater and agricultural runoff has caused extensive pollution of the receiving water bodies. This waste is in the form of raw sewage, detergents, fertilizer, heavy metals, chemical products, and even solid waste. Untreated wastewater affects health by transmitting disease-causing microorganisms, makes water unsafe for drinking and recreational use, impairs biodiversity, and degenerates the overall quality of life (World Bank, 2003).

While the city officials recognize emerging water quality problems brought about by untreated waste water and poor sewerage system, they are constrained by high investment and operating costs, limited willingness-to-pay, restricted space available in the low-income urban areas where sewage is disposed of indiscriminately (World Bank, 2003).

Non-SCWD Calculated Annual Production Volume. Some barangays may have organized Barangay Water and Sanitation Associations (BAWASAs) or barangay-managed water facilities whose freshwater sources are deep wells, springs, and others. Data from the CENRO (2016) revealed that there are 17 BAWASAs that exist in barangays not covered by the SCWD. In addition, there were nine water facilities managed by the local government and nine other facilities using various sources like wells and water refilling stations.

In the Philippines, there are three levels of water supply which are regulated by the local government code. Level 1 refers to water supplied by wells or springs in the villages, Level 2 water is supplied by

public (communal) water faucets, and Level 3 water is supplied through water faucets in individual households (Nakagome & Takagi, 2008). Levels 1 and 2 are under the jurisdiction of municipalities, whereas Level 3 water supply is under the jurisdiction of Water Districts. The Local Water Utilities Administration (LWUA) is a government agency, which supports establishment of the Water Districts in rural areas, improvement of water facilities and their administration through the lending of funds and providing operational support, such as managerial and technical guidance. Water Districts are organizations established in 1973 following the Presidential Decree No. 198 (PD 198). The Water Districts supply water at Level 3 in provincial cities with a population of more than 2 million (Nakagome & Takagi, 2008).

Sorsogon City is vulnerable to natural calamities, which in turn highlighted the vulnerability, especially of the poor, to the loss of water sources and to the increased cost of water delivery and to the destruction of water and sanitation facilities. While the city does not manage a designated watershed, the continuing degradation of water resources coupled with fast population increase signal a need to help ensure the sustainability of water sources.

The local government should also target the disadvantaged groups (e.g., women headed households and poor households in the slum areas) and other unserved and underserved areas for appropriate water services such as communal water points in collaboration with the city and barangays. This may also be through easy installation plans that expand the reach of water service benefits while maximizing cost recovery.

Throughput (Utilization)

Utilization of resources locally extracted include: use of water for domestic purposes—utilization of water for drinking, washing, bathing, cooking, and other household needs, as well as for home gardens and domestic animals; use of water for municipal purposes—utilization of water for supplying the water requirements of the community; use of water for commercial/industrial purposes—utilization of water in factories and industrial plants; use of water for irrigation—utilization of water for producing agricultural crops, and use of water for recreational purposes—utilization of water for swimming pools, bath houses, boating, water skiing, golf courses, and other similar facilities in resorts and other places of recreation.

SCWD's Annual Billed Volume. Of the city population, 81.84% has access to safe water through the SCWD, a Level 3 water supply service defined by the National Economic and Development Authority as "a fully reticulated system with individual house connections based on a daily water demand of more than 100 liters per person."

However, the fact still remains that, as of 2016, one-fifth of the population or 33,600 residents do not have continuous running water in their homes (LGU-Sorsogon, 2016). In terms of barangay-level access, only half of all barangays in Sorsogon City are connected to the SCWD. These are the more sparsely populated barangays, so city-level data show a high piped-in water access as percentage of the population.

Water utilization for irrigation and recreation, as well as runoffs, cannot be calculated because there are no available data from the Department of Agriculture (DA) and the National Irrigation Administration (NIA). No recycling of wastewater is done in Sorsogon city. Household wastewater was calculated at 2,525,120.63 m^3/annnum, while that from commercial and industrial plumbing is 1,227,203 m^3. Public institutions generate 141,196 m^3 of wastewater. Meanwhile, the public market and the slaughterhouse—the only places with wastewater treatment facilities—collected and treated 32,850 and 4,136.05 m^3, respectively, of wastewater in 2016. Since Sorsogon City does not have a centralized sewerage and treatment facility, most wastewater from household plumbing goes directly to nearby bodies of water.

Non-SCWD Domestic Consumption. During the FGD with barangay captains and members of BAWASAs, it was discovered that most of the water facilities are Level 3 with chlorination conducted every month. These facilities are sustained through tariff collection ranging from ₱7.00 to ₱15.00 per m^3, but a number are free. Some water facilities cannot operate 24 hours a day, so a two-hour water supply rotating schedule is imposed to distribute water equitably to the covered areas. This is the only way they can distribute water to all households, albeit not 24/7. Water directly coming from deep wells is used for washing and bathing only. Septic tanks near water sources, open defecation, piggeries, and stray animals are identified as contamination hazards for these water sources.

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Output

The total population is not connected to a sewerage system. The clear majority uses flush toilets connected to septic tanks or systems that are underground wastewater treatment structures using a combination of nature and proven technology to treat wastewater from household plumbing produced by bathrooms, kitchen drains, and laundry. Since sludge treatment and disposal facilities are rare, domestic wastewater (waste in liquid state containing pollutants) is discharged without treatment. Some estimates point to household wastewater as contributing as much as 60% of water pollution, while about 80% of water provided to households becomes wastewater (World Bank, 2003). Septic tanks are prevalent but they are generally undersized and single-chambered, while their bottoms are commonly unlined and regular desludging is not practiced. Most of the time, discharge is directed to drainage canals. This persists even if desludging is a legal requirement to empty septic tanks or sewage treatment plants regularly. Emptying the tanks regularly ensures that the system operates effectively and remains safe and odor-free. Meanwhile, the CENRO does not have the exact figure of household wastewater and sludge produced per year.

The city health officer of Sorsogon City revealed that 86% of households have sanitary toilets as of 2016. The 14% with no toilets would use their neighbors' bathrooms or practice open defecation. Most of these households are informal settlers who lost their homes due to road-widening projects. Some used to be coastal inhabitants who were forced to relocate due to threats of storm surge while others are from the neighboring towns seeking livelihood in the city. The city health officer added that most public spaces such as schools, daycare centers, rural health units, public markets, terminals, and ports have public toilets and handwashing facilities. Moreover, food manufacturing industries, piggeries, and slaughterhouses are the main sources of organic pollution. There are no estimates of hazardous wastes generated by industrial establishments per annum in Sorsogon City.

At present, there is no integrated treatment facility in the city, although there are two small-to medium-scale treatment facilities or decentralized wastewater treatment systems (DEWATS) that treat wastewater, according to the CENRO. It revealed that only the wet market's and the slaughterhouse's liquid wastes are collected and treated. The facilities in these locations are DEWATS operated and maintained by the LGU. The system includes an anaerobic lagoon where organic matter is digested by anaerobic microorganisms, a facultative lagoon where suspended organic matter is digested by both aerobic and anaerobic bacteria, a third lagoon where liquid waste is digested by aerobic bacteria, and finally, the wastewater passes through an engineered bed pond. This engineered reed bed has sand and gravel planted with reed grass whose roots are used to filter water coming from the maturation lagoon. The pond contains live tilapia as a determinant if the treated water is suitable for discharge to creeks and rivers. The sludge drying bed constructed in the middle and elevated portion is the drying area of sludge, intestinal contents, and other inedible materials.

The Input-Throughput-Output Analysis of Water Consumption

The input-throughput-output analysis on water and sanitation was done using a simplified version of Barle's (2009) method, which states that the input should be equal to the sum of the utilization and output. Table 1 shows that the input was 5,310,486 m^3/annum while utilization/output was 6,861,715.26 m^3/annum which had a difference of 1,551,229.26 m^3/annum. The disparity between the input and the sum of the utilization (throughput) and output may be attributed to run-offs that become part of surface and ground water where no datais available as well as leakages from pipes and connections.

The city's water facilities locally extract water from the Cawayan River, 13 deep wells, and four springs. Sorsogon City's annual local extraction is 5,310,486 m^3 broken down as follows: SCWD's annual production volume is 3,292,566 m^3/annum, while non-SCWD annual local extraction is calculated at 2,017,920 m^3. The calculation was based on the number of households not covered by SCWD multiplied by 16, which is the average unit consumption multiplied by 12. The 33% of the total households not serviced by SCWD may have their organized BAWASAs as their water service providers.

According to the SCWD, the non-revenue water (water loss) is pegged at 26.83%. This implies a diminution in effective water supply vis-a-vis an increasing demand requirement that could raise the consumer price of water. Essentially, the SCWD incurs additional cost to recover the system loss. Consequently, the decrease in the supply and increase

in price of water would also affect the health and sanitation services of the locality. Needless to say, while future water demand is expected to increase significantly, the existing water supply facilities are to a large extent in a state of deterioration, and repair of water facilities is therefore essentially needed. The water district hopes that the existing service coverage will eventually be expanded to include the un-served population within the existing service area and additional areas.

SCWD management is aware of the need to reduce non-revenue water (NRW), which occurs through physical losses from leaking and broken pipes caused by inefficient operations and maintenance, the lack of active leakage control, and poor quality of underground equipment. It also comes from commercial losses brought about by the under-registration of customer meters, data handling errors, illegal connections, and water theft. Likewise, NRW is caused by unbilled authorized consumption, which includes water used for firefighting, and water used for free by certain consumer groups (Public-Private Infrastructure Advisory Facility [PPIF], 2006).

The sources of water within the territory of Sorsogon City can sustain supply of water for its populace for the years to come, provided its water management technology (extraction, treatment and distribution) is periodically upgraded to lessen, if not totally avoid, system losses. A unified set-up of water resource management system instead of the current two-entity operation (SCWD and non-SCWD) will facilitate technology upgrading for a more efficient delivery of service. Sixty-two percent of local water extraction is done by the SCWD, while 38% is done by BAWASAs and other entities. The former serves 81.84% of water consumers in Sorsogon City, while the 18.16% is served by the latter. Based on the projected water production of the SCWD, the water demand of the city for the next decade can be met even if the water utility increases the number of households with service connection. However, even with abundant sources of water, Sorsogon City must adopt new water management technologies that will make water production and consumption sustainable in the short, medium, and long terms. In addition, environment-friendly practices (including planning and regulation) must be developed and implemented by the city so that its water sufficiency is maintained for generations to come.

According to Jalota and co-workers (2018), Water extraction for human consumption is a major cause of reduced baseflow or the flows occurring in the absence of overland runoff. They added that water extraction can occur directly from dams, in river reaches downstream of dams or from groundwater storages that are connected to surface water ecosystems. When water is extracted directly either from dams or unregulated rivers, flow volume is reduced and can lead to much lower flows than expected under natural conditions or even the complete cessation of flow in what would normally be perennially flowing streams (Jalota *et al*., 2018). Removal of water from groundwater also reduces streamflow in connected surface water systems (Cheremisinoff, 1997).

Wastewater is used water, which includes substances such as human waste, food scraps, oils, soaps and chemicals. In homes, this includes water from sinks, showers, bathtubs, toilets, washing machines, and dishwashers. Businesses and industries also contribute their share of used water that must be cleaned. Much of the water used by homes, industries, and businesses must be treated before it is released back to the environment. If wastewater is not properly treated, then, the environment and human health can be negatively impacted. These impacts can include harm to fish and wildlife populations, oxygen depletion, beach closures, and other restrictions on recreational water use, restrictions on fish and shellfish harvesting, and contamination of drinking water (U.S. Geological Survey [USGS], n.d.).

Wastewater treatment is the process of converting wastewater into bilge water that can be disposed of into the environment. It aims at reducing the wastewater contaminants to acceptable levels to make the water safe for discharge back into the bodies of water (Kukreja, 2016). Rola and co-workers (2018) enumerated different characteristics of water, namely water production involves economies of large scale which are evident in water storage, conveyance, and distribution, water is mobile which occurs both as stock (ground water) and as flow (surface water), water is not entirely consumed by any particular user but by many and varied entities, and water is nearly a universal solvent because it assimilates water and pollutants.

The growth of Sorsogon City will always threaten its sustainability. This is a part of the urbanization process, and the LGU must mitigate and manage these threats to facilitate the flow of water and other

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resources. However, city leaders should not be confined to the conventional practice of issuing resolutions and ordinances, which are curative and prescriptive in nature. Creative thinking and strong governance must be given priority to come up with preventive measures in conjunction with the anticipated effects of urbanization.

Effective utilization of water may reduce both the need for good quality water and the volume of wastewater produced. Reducing the amount of wastewater sent to treatment facilities may improve the overall process performance by reducing the hydraulic loading and, in some cases, providing a more sustained wastewater flow. The major aim of wastewater treatment is to protect human health and prevent environmental degradation by the safe disposal of domestic and industrial wastewater generated during the utilization of water. Edokpayi and co-workers (2017) reported major factors responsible for the failure of wastewater treatment facilities in developing countries, which includes poor operational state of wastewater infrastructure, design weaknesses, lack of expertise, corruption, insufficient funds allocated for wastewater treatment, overloaded capacities of existing facilities, and inefficient monitoring for compliance, among others. The decision to use water more efficiently reduces water needs and wastewater generation. An important first step to water conservation is to realize how much water various human activities use and initiate water saving activities. Likewise, prompt repair of leaking faucets and toilet valves may minimize water wastage.

Wastewater discharges are major contributors to various water contamination and pollution problems. Majority of cities of developing countries produce on the average 30–70 mm^3 of wastewater per person per year (Edokpayi *et al*., 2017). Due to lack of or inefficient wastewater treatment facilities, wastewater effluents (domestic and industrial wastes) are often disposed of into water courses such as creeks, rivers, and lakes, which may result in pollution and degradation. Hence, wastewater materials should be treated efficiently and effectively in order to avoid the adverse health risks of the users of surface water resources and the aquatic ecosystem. The disposal of untreated wastewater into surface water sources may have both short and long-term effects on human health and the environment. Hence, there should be strict enforcement of water and environmental laws to protect the health of residents of both rural and urban communities.

Conclusion

The input (water extraction) is not equal to the sum of the throughput (utilization) and output (waste water) of water and sanitation in Sorsogon City; hence, the city has not efficiently managed its water and sanitation resources as evidenced by partial coverage of its Level 3 water facility, high system losses, absence of centralized sewerage system, and inadequate waste water facility which puts water sources at risk for microbial contamination.

The following recommendations are forwarded to the Sorsogon City Local Government Unit officials: the SCWD's coverage must be expanded to unserved barangays, the city's water management system (extraction, treatment, and distribution) must be periodically upgraded to minimize, if not totally avoid, system losses. A unified setup of water resource management instead of the current two-entity operation (SCWD and non-SCWD) must be implemented in order to facilitate technology upgrading for a more efficient delivery of service. Additionally, the city must create a centralized sewerage system and put up biological, physical and chemical waste water treatment facilities in order to prevent contamination of its water sources and pollution of its bodies of water, which may have great impacts on the health of its people and the environment. Lastly, not only the quantity, but also the quality, of water used for domestic, institutional, and commercial purposes must be maintained in order to prevent water-borne diseases and promote better health towards a more efficient and progressive Sorsogon City.

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