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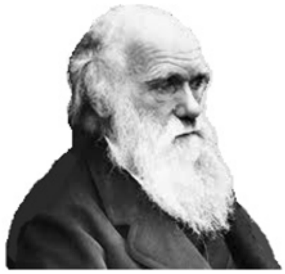

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Performance of Community Water Supply Management towards Designing Water Safety Plan

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ABSTRACT

Potable water is a commodity and basic necessity of life for which metropolitan areas and adjacent areas are to pay. Water from Manila Waterworks and Sewerage System (MWSS) has also become a problem considering the low water supply coming from their sources. Because of El Nino phenomena and other problems of the water system, rationing Metro Manila was implemented. This descriptive study aimed to assess the performance and effectiveness of community water supply management in terms of the quality of water such taste, odor, color, sediments, service and cost and design water safety plan for the community. Purposive sampling was used to determine the participation of the knowledgeable homeowners of Karangalan Village in the province of Rizal. Some interesting insights of the study are: Potable water is the water delivered to the homeowners. However, there are sediments and brownish color observed in the water due to pipe corrosion. In terms of service, the performance of the water system delivered to the homeowners is acceptable based on the volume delivery, accessibility, availability, promptness, and reliability. Homeowners who use potable water are satisfied in terms of its efficiency, effectiveness, user-friendly, promptness and expandability. Water safety plan is an integral part of the whole planning process and helps improve the management of Karangalan village water supply and may be undertaken or updated at any time

***Keywords*:** Water distribution, water management, water resources, water supply

1. INTRODUCTION

The Philippines views water supply as a basic need and it is a requirement for economic development. The Manila Water Company (MWCO), under Republic Act No. 6234 as amended, is mandated to ensure an uninterrupted and adequate distribution of potable water for domestic and other purposes, and the proper operation and maintenance of sewerage system in its service area comprising of Metro Manila and the provinces of Cavite and Rizal (Ganiron Jr, 2016). However, Manila Water Company (MWCO) existing supply has a volume capacity of 2000 million liters per day (ml/d) which means 65% capacity to supply its service area coverage (Bohm, 1993). Indirect consumer mostly blighted areas outside of the central distribution system, presently apportion an average of about 4% of household income to purchase water from other vendors at 10 pesos per cubic meter or even higher (Baltazar, 1988). Aside from a chronic lack of water supply in Cavite and Rizal, the population is also exposed to public health problems associated with drinking water. The Department of Health (DOH) is responsible for public health, preventive curative and rehabilitative programs, health, and medication services. Statistics show that diarrhea morbidity rates in the Philippines range from 1,520 per 100,000 populations (Ganiron Jr, 2016). Morbidity due to water-related diseases such as a typhoid fever, infections, and hepatitis also increased these years (Munasinghe, 1992).

1. 1. Strategic Issues

Philippines water resources are under mounting stress because of rapid population growth, increasing demand for food production, urbanization, pollution, excessive and inefficient use of water, and climate change. Ensuring adequate availability of water in the future will require protecting the Philippines water sources through improvement of catchment areas and watershed protection, regular assessment and monitoring of consumption patterns and trends, and efficient allocation of existing water supplies (Malzer, 2010). All of the latter need to be taken into account in the institutional decision-making framework. The challenge is to assess and manage water resources comprehensively, covering urban and rural areas in a holistic manner (Krishna, 1997).

Water supply coverage has not kept pace with the growing population in the last few decades. Many water utilities face financial difficulties because tariffs are too low to recover costs and systems are too small to work efficiently (Dyek, 2007). Persistent problems in water supply include (i) institutional fragmentation, (ii) weak sector planning and monitoring due to lack of sector information, (iii) poor performance of many water utilities, (iv) low public and private sector investment and limited access to financing for service expansion, and (v) inadequate support for poor urban communities and rural water utilities. The challenges posed by sanitation are even greater. Few households are connected to a sewerage network (less than 5% by most estimates). The majority of households with toilets are connected to septic tanks that are poorly designed or maintained, therefore, the most effluent is likely to be discharged without treatment (Bennett, 2012). Weak management of solid waste and sanitation is a large challenge since this contributes to contamination and pollution of surface and ground water sources (Bakker, 2008). Problems include (i) lack of policies and effective governance and regulation, (ii) low levels of awareness and political will for improving sanitation; (iii) inadequate funds for financing infrastructure; and (iv) lack of sanitation capacity.

Another issue in drinking water management is the effect of drought on groundwater supplies (Tabbal, 2002). Drought can result in a decrease of recharging of ground water. This will lower the water table, thereby, encouraging over-pumping of wells. In Cebu, where there has been costly salt-water intrusion (Duineveld, 2004). Also, with so many foreign and domestic companies enjoying favored status during the modern push for industrial growth, there has been a lack of watchdog organizations to index, track, and regulate hazardous waste disposal according to national standards (Sobsey, 2002). It is likely that some parts of the Philippines will pump their aquifers to the point they draw hazardous wastes horizontally from landfills and septic tanks. A partial list of industrial pollutants can be helpful in understanding the wide variety of industrial hazards that exist (Bohm, 1993). One example of an extremely hazardous chemical that may be found in water near nylon manufacturers is caprolactam (Ahmed, 2006)). Again, proper classification, regulation, enforcement, and use of best available technology to track and treat pollutants may help reduce the risk of such hazards, especially during times when natural hazards such as drought or flooding occur (Summerill, 2010)

Perhaps the most disturbing thing about Manila's distribution system is that it lacks strategically placed backflow preventers. Backflow can occur when pressure drops in a water line (Yoshioka, 1989). This means cholera, and other water-borne diseases could gain rapid access to millions of people and could cause a catastrophic epidemic of one or more water-borne diseases (Bamstedt, 1976). Contamination of drinking water remains a problem in rural areas where deep well, common faucets and sometimes water direct from streams or springs are the available sources which do not undergo proper water treatment before it is consumed. In 2010 and 2011, results of the morbidity reports for water-borne diseases from rural health unit in Samar and the hospital was alarming (Moe, 1991). Acute gastroenteritis, cholera, and typhoid fever ranked first Thus, this study aimed to assess the performance and effectiveness of Karangalan Village water supply management in terms of quality of water such as taste, odor, color, sediments, service and cost (Korten, 1982)

2. HISTORICAL BACKGROUND

Karangalan Village in the province of Rizal, which is the setting of the study, is a 78.6 hectares village. It is located in Felix Avenue, Cainta which is situated in the eastern part of Metro Manila. Sixty percent (60%) of lots is occupied by homeowners (Ganiron Jr, 2016). The area is characterized by a relatively flat terrain with an elevation from 15.4 to 17.2 meters (Fawcett, 1998). Significantly, the area forms part of Metro Manila within the fringes of MWCO's Central distribution system. Today, MWCO's existing supply capacity cannot accommodate Karangalan Village. The completion of the Umiray Angat Transbasin Project (UATP) would benefit this area on its commissioning by 2017 if it were not for the scarcity of water supply. Thus, implementation of an interim water supply improvement project should be undertaken to meet the demand of the study area until the advent of the proposed Manila Water Supply 111 project (Kariuki , 2005)

Currently, the area, with a population of 5.061 households is being served by four (4) deep wells (Kinniburgh, 2001). These deep wells were constructed from 1980 to 1985. However, one (1) deep well located in Phase 11 is abandoned, while three (3) deep wells are operational at the moment. The total discharged of the operational deep wells is an averaged at 1.6 ml/d. The existing demand of 1.78 ml/d cannot be met by the three existing groundwater sources, water supply scarcity of Karangalan Village will be aggregated by the projected total population of 8,436 or and effective demand of 3.3 ml/d (Esrey, 1991). Most of Karangalan Village is experiencing intermittent water supply from its deep wells, particularly at Phase 2 and Phase 3. Other residents use shallow wells for domestic purposes (Esrey, 1991).

This study intends to study the water supply improvement of the area through the rehabilitation of existing wells, the augmentation of the supply source through the construction of deep wells, or a combined utilization of groundwater and surface water sources.

Operation and maintenance are the basic necessity that Karangalan Village residents should have access to reliable water supply and the necessary skills, equipment and other related aspects for the upkeep of its water supply system (Bartman, 2009). Residents in need of an improved supply and services should be provided initially with low-cost solutions for financial reasons. Installation of a shallow well for a household is estimated 35,000 pesos in capital cost (Nolan, 2006). This may not be feasible within the area.

3. RESEARCH DESIGN AND INSTRUMENTATION

3. 1. Research Design

The study used the inferential and descriptive methods of research with questionnaires as the main data-gathering instrument. The subjects of this study were the homeowners of Karangalan Village located in the province of Rizal. In 2011, the record shows that there are 1000 households in this area. Purposive sampling was utilized in order to determine the participation of the knowledgeable homeowners only by considering those who meet the three criteria. The criteria are (1) College graduate; (2) Work in the government or private company; and (3) Minimum of three (3) years of residence in Karangalan Village.

3. 2. Instrumentation

The major tool for data gathering was the questionnaire. The questionnaire was divided into 3 parts. The first part dwelt on the status of homeowners in terms of demographic variables. The second part focused on the quality of existing deep well in terms of the quality, service, and cost of water. The third part pertains to the level of adequacy of water in terms of operational related factors. The final draft of the questionnaire was pretested by an initial group of 7 prospective respondents and their comments and suggestions were incorporated in the final draft. The initial group, however, was not included in the respondent group whom the final questionnaire was administered. To further ensure the validity of the questionnaire, the researcher read various books regarding institutional relations and corporate values in order to develop appropriate questions and choices. Likewise, the researcher also repeatedly went to the prospective respondents and asked them about the possible questions that could be asked in relation to the research topic. The researcher also used the unstructured interview. It was administered to the respondents to further clarify the opinions reflected in the questionnaire. Statistical tests of mean and percentage values were used to enable researcher to give appropriate responses to the statement of the problem

3. 3. Statistical Treatment of Data

All the data gathered treated using the following tools.

Percentage

The percentage score was computed by the number of responses divided by the total number of the subjects and the quotient multiplied by one hundred. This method was helpful in interpreting subjects and subgroups having unequal sizes as in the cases of the sample characteristics of the respondents

The formula is

$$\% = (f/N) \times 100$$

where : f = frequency of responses

N = number of cases/responses

Weighted mean

The mean of the answers was determined to provide the average option. It was computed using the following formula:

$$X = \sum (wx)/N$$

where : $\sum$ = symbol for summation

X = mean

w = weighted of each item

x = item value

This formula was used to measure the performance of the existing deep well in terms of quality of water delivered, service of the water and its cost effectiveness. Similarly the same was used in finding the level of adequacy of a deep well as regards to some operational related factors. Tables 1 and 2 show the criteria that served as the basis for interpretation of the result was adapted from the concept of boundary made as follows.

Table 1. Rating scale for the performance of the existing deep well

Mean	Interpretation	Abbreviation
4.50-5.00	Very Satisfactory	VS
3.50-4.49	Satisfactory	S
2.50-3.49	Fair	F
1.50-2.49	Poor	P
1.00-1.49	Very Poor	VP

Table 2. Rating scale for the level of adequacy of the existing deep well

Mean	Interpretation	Abbreviation
4.50-5.00	Very High	VH
3.50-4.49	Above Average	AA
2.50-3.49	Average	A
1.50-2.49	Below Average	BA
1.00-1.49	Very Low	VL

4. SAMPLE CHARACTERISTICS

Karangalan Village in the province of Rizal, which is the setting of the study, is a 78.6 hectares village. It is located in Felix Avenue, Cainta which is situated in the eastern part of Metro Manila. Sixty percent (60%) of lots is occupied by homeowners (Ganiron Jr, 2016). The area is characterized by a relatively flat terrain with an elevation from 15.4 to 17.2 meters (Fawcett, 1998). Significantly, the area forms part of Metro Manila within the fringes of MWCO's Central distribution system. Today, MWCO's existing supply capacity cannot accommodate Karangalan Village. The completion of the Umiray Angat Transbasin Project (UATP) would benefit this area on its commissioning by 2017 if it were not for the scarcity of water supply. Thus, implementation of an interim water supply improvement project should be undertaken to meet the demand of the study area until the advent of the proposed Manila Water Supply 111 project (Kariuki , 2005)

4. 1. Age

Of the 305 respondents in this study, 28.9% fell into the category of 36 to 40 years old, 24.6% were 26 to 30, and 21.6% were 31 to 35 years old. Table 3 indicates that the respondents in the community where the households are relatively young.

Table 3. Frequency and percentage distribution of respondents based on age

Age (years)	Frequency	Percentage (%)
below 20	1	0.3
21-25	2	0.7
26-30	75	24.6
31-35	66	21.6

36-40	88	28.9
41-45	26	8.5
46-50	22	7.2
51-55	11	3.6
56-60	10	3.3
Above 60	4	1.3
Total	305	100

4. 2. Gender

156 or 51.1% were male and 149 or 48.9% were female. Table 4 reveals that males in the subdivision or the head of families are very interested and active in participating the survey for this study.

Table 4. Frequency and percentage distribution of respondents based on gender

Gender	Frequency	Percentage (%)
Male	156	51.1
Female	149	48.9
Total	305	100

4. 3. Civil Status

The respondents in this study, 65.6 % were married and 34.4% were single. Table 5 shows that the respondents in the community are mostly married, indicating a more mature and committed group.

Table 5. Frequency and percentage distribution of respondents based on civil status

Civil status	Frequency	Percentage (%)
Married	200	65.6
Single	105	34.4
Total	305	100

4. 4. Educational Attaintment

The majority of the respondents shown in table 6, 78.7% obtained Bachelor degree 19.3 %, obtained a masters' degree and 2% finished doctorate degree. Overall, the respondents in the community appear to be educated holding a bachelor degree.

Table 6. Frequency and percentage distribution of respondents based on educational attainment

Educational Attainment	Frequency	Percentage (%)
Bachelor degree	240	78.7
Masters' degree	59	19.3
Doctorate degree	6	2.0
Total	305	100

4. 5. Monthly Income

The respondents in this study, 54.8 % received a monthly income between P20,000-P25,000, 29.5% received a monthly income between P25,000-P30,000 and 15.4% received a monthly salary below P20,000. Table 7 indicates that the respondents in the community are middle-income earners.

Table 7. Frequency and percentage distribution of respondents based on monthly salary

Monthly salary (PHP)	Frequency	Percentage (%)
below 20,000	47	15.4
20,000-25,000	107	54.8
25,000-30,000	90	29.5
above 30,000	1	0.3
Total	305	100

4. 6. Nature of Employment

The respondents in this study, 70.2 % are working in the government and 29.8% are with private organizations. Table 8 reveals that the residents in the community prefer to work in the government rather than the private organizations because of fringe benefits and security of tenure offered by the government to the workers.

Table 8. Frequency and percentage distribution of respondents based on nature of employment

Nature of employment	Frequency	Percentage (%)
Government	214	70.2
Private	91	29.8
Total	305	100

5. FINDINGS

5. 1. Performance of existing deep well in terms of quality of water delivered

Respondents' perception that the quality of water delivered has an overall mean of 3.27 which is fair. Table 9 reveals that potable water is the water delivered to the homeowners. However, there are sediments and brownish color observed in the water due to pipe corrosion. Rusty water occurs from sediment in the pipes or rust from the inside walls of the water mains. This discolored water is not a health threat.

Table 9. Perceptions of respondents on performance in terms quality.

Quality of water	Mean (X)	Interpretation
Taste	3.57	Satisfactory
Odor	3.55	Satisfactory
Smell	3.55	Satisfactory
Presence of Sediments	2.54	Fair
Color	2.73	Fair
Potability	3.70	Satisfactory
Overall mean	3.27	Fair

5. 2. Performance of existing deep well in terms of service

Respondents' perception regarding the water performance in terms of service has an overall mean of 3.60 which is satisfactory. Table 10 reveals that service delivered to the homeowners is acceptable based on the volume delivery, accessibility, availability, promptness, and reliability.

Table 10. Perceptions of respondents on performance in terms of service

Service	Mean (X)	Interpretation
Volume delivery	3.64	Satisfactory
Accessibility	3.60	Satisfactory
Availability	3.53	Satisfactory
Promptness	3.62	Satisfactory
Reliability	3.61	Satisfactory
Overall mean	3.60	Satisfactory

5. 3. Performance of existing deep well in terms of cost-effectiveness

Respondents' perception that the performance of water in terms of cost effectiveness has an overall mean of 3.78 which is satisfactory. Table 11 reveals that homeowners who use water are satisfied in terms of its efficiency, effectiveness, user-friendly, promptness and expandability.

Table 11. Perceptions of respondents on performance in terms of cost-effectiveness

Cost effectiveness factors	Mean (X)	Interpretation
Efficiency	3.77	Satisfactory
Effectiveness	3.75	Satisfactory
User-friendly	3.67	Satisfactory
Promptness	3.82	Satisfactory
Expandability	3.87	Satisfactory
Overall mean	3.78	Satisfactory

5. 4. Performance of existing deep well in terms of operational-related factors

Respondents' perception on the level of adequacy as regards to operational related factors has an overall mean of 3.67 which is very high. Table 12 implies that the officers manning the water system are experienced personnel. Most of the personnel are capable of doing any job maintenance whenever there are emergencies.

Table 12. Perceptions of respondents on level of adequacy.

Operational related factors	Mean (X)	Interpretation
1. The water system is manned by skilled personnel.	3.72	Very High
2. The water has an operating system	3.70	Very High
3. Personnel manning the water system are capable in case there are emergencies.	3.60	Very High
4. Procedures are strictly followed in the operation of water system	3.67	Very High
Overall mean	3.67	Very High

6. CONCLUSIONS AND RECOMMENDATIONS

Findings reveal that Karangalan villages' deep wells have proven very effective due to their locally available technology and low cost. Their deep well is constructed and fitted with hand-pumps. They have proven sustainable in supplying potable water. Therefore, with proper consideration for local hydrogeology (ground water quality, fluctuations levels and potential for pollution), the ground wells will effectively provide potable water to many people in this community. However, there are sediments and brownish color observed in the water due to pipe corrosion. The rust can be disturbed and temporarily suspended in water with unusual water flows from water main breaks or maintenance or by flushing of a hydrant. This discolored water is not a health threat. When the water is discolored it is recommended to either not wash laundry or to use a rust stain remover or regular detergent but not chlorine bleach as it will react with the iron to form a permanent stain. If old, rusty pipes are discoloring the water, get an advice from a licensed of plumbing materials or an experienced plumber. Water that is being discolored by rusty pipes is not a health hazard; however, it is an indication that the pipes are corroding and they can eventually leak.

7. WATER SAFETY PLAN FOR KARANGALAN VILLAGE

After evaluating the results of the foregoing findings, a proposed water safety plan for Karangalan village was drawn. In Figure 1, water safety plan have been illustrated that might be effective for Karangalan village.

It is up to Karangalan village community to determine how best to achieve this water safety plan. Water safety plan is an integral part of the whole planning process and helps improve the management of Karangalan village water supply and may be undertaken or updated at any time.

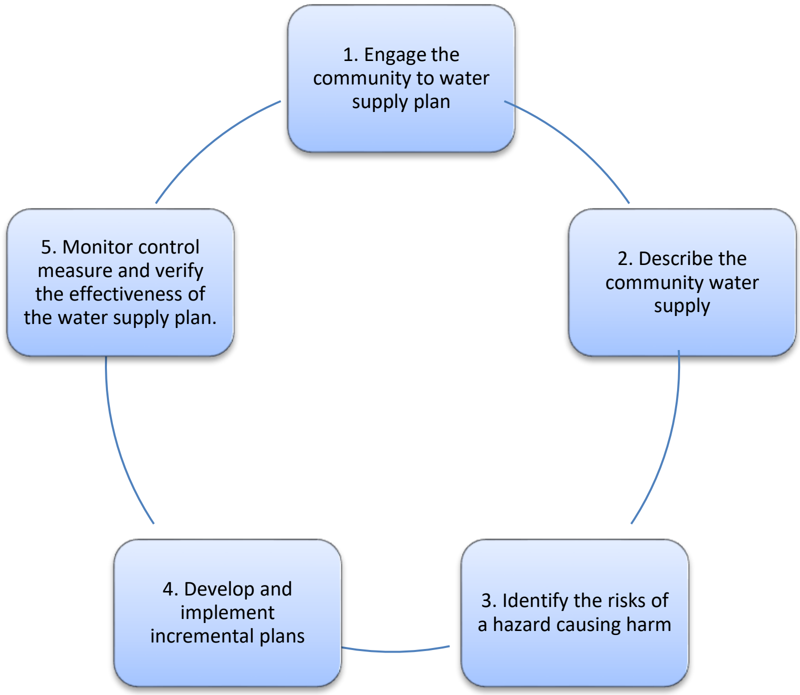

Figure 1. Water safety plan

7. 1. Engage the community to water safety plan

The Karangalan village as a whole can be engaged in a number of ways. It is generally more efficient and effective to identify suitable members of the community to represent the community's interests as part of a water supply plan team. Other methods of engagement include, for example, public meetings, participatory techniques and subgroup meetings by service areas or interest groups. A visit to a nearby community that has successfully applied a water safety plan is a good way to trigger interest in the approach.

7. 2. Describe the community water supply

An easy way to do this is to make a map/flow diagram of the water supply, including relevant elements of the catchment area and the community served. A great deal of information can be recorded and presented in a drawing. Such mapping of the community water supply from catchment to consumer is an essential part of the water supply description.

General information also needs to be gathered and recorded to describe the water supply and its management, including the various sources in use. It is important to physically check the description of the water supply system through a walk or site inspection. Taking photos and reviewing related documentation can also be useful. The water supply map and description should be updated based on this check.

7. 3. Identify the risks of a hazard causing harm

It is also good practice to keep track of events and risks that may arise due to changes in or around the system as a result of land use changes, construction, and industry. Hazard identification should be based on community knowledge including historical information, and recurring local events such as heavy runoff or floods during heavy rainfall periods (Ganiron Jr, 2015). Keeping the water safety plan up to date and valid is critical and will pay off in reduced risk and less damage during unexpected events.

When identifying hazards and hazardous events, first look for signs that may signal issues caused by contaminated water supplies. The simplest risk assessment method is the descriptive risk assessment. In this approach, the hazards and hazardous events are prioritized based on the team's judgment. For each hazard and hazardous event, consider the significance of each risk, reflecting on and recording how likely it is that the event will occur in the community and how serious it might be, along with a consideration of the effectiveness of any existing control measures that are in place to mitigate those risks. Discuss and compare each listing until it agrees on which issues are of greater or lesser importance. Write down the issues in order of importance and double-check the entire list to make sure that it makes sense. The second risk assessment approach is a more formal, two-step process. This method can be applied if the community has some higher-level support such as water quality unit of the district water agency or a public health inspector or additional resources in the community.

Identify any existing control measures or barriers that are already in place and that address potential hazards and hazardous events. Control measures can be technical (e.g. disinfection), infrastructural (e.g. fencing), behavioral (e.g. pesticide use) or related to planning (e.g. land use). It is very important to assess whether these existing barriers are effective at eliminating or reducing the identified risks; it should not be taken for granted that they are working properly. If control measures are ineffective or are not currently in place for an identified significant risk, this should be noted and suggestions for improvement listed.

7. 4. Develop and implement incremental plans

Review its available resources and the community's needs against the information from the risk assessment to identify which water safety improvements should be implemented with priority and which can be deferred for the medium or long term. When considering work to reduce or eliminate a risk, positive spin-offs, such as the opportunity to make the service more reliable or extending the service area, should be looked at. Comparing costs against all the benefits may generate more interest in supporting the planned work. The incremental improvement plan will be a powerful tool to ensure that limited funds, from both within and outside the community, will be used most effectively

7. 5. Monitor control measure and verify the effectiveness of the water safety plan

This is to confirm that the community water supply is operating as expected and that the water safety plan is protecting drinking water safety and public health. In operational monitoring, there is a planned and ongoing observation using checklists for visual on-site inspection and simple water quality measurements to assess whether a community water supply is operating normally—that is, whether the control measures to prevent, remove or reduce contaminants are operating effectively as planned. Operational monitoring of control measures enables timely detection of operational and water quality problems so that action can be taken prior to the supply of unsafe drinking-water while verification monitoring confirms that water quality targets or objectives are being achieved and maintained and that the system as a whole is operating safely and the water safety plan is functioning effectively. It is typically based on compliance monitoring, internal and external auditing of the adequacy of the water safety plan and adherence to operational activities, and checking consumer satisfaction. In auditing, sanitary inspection formats are often a useful tool for confirming that measures put in place effectively control previously identified risks.

Biography

Dr. Tomas U. Ganiron Jr received the doctorate degree in Construction Management in Adamson University (Philippines), and subsequently received his Master of Civil Engineering major in Highway and Transportation Engineering at Dela Salle University (Philippines). He is a registered Civil Engineer in the Philippines and Professional Engineer in New Zealand. Aside from having more than two decades of experience as a professor, department head and researcher in the Philippines and New Zealand, Dr. Ganiron Jr is a practicing Civil and Construction Engineer for 20 years, having designed and supervised projects such as sewerage and waterworks structures, ports and marine structures, water treatment plant, and structural buildings and bridges. He is also very active in other professional groups like Railway Technical Society of Australasia and Australian Institute of Geoscientists where he became the committee of Scientific Research. He has received the Outstanding Civil Engineer in the field of Education given by the Philippine Media Association Inc. (1996), ASTM Award CA Hogentogler (2008) awarded by International Professional Engineers New Zealand and Plaque of Recognition as Outstanding Researcher (2013) given by Qassim University-College of Engineering.

References

[1] Ahmed, M. F., Ahuja, S., Alauddin, M., Hug, S. J., Lloyd, J. R., Pfaff, A., & Van Geen, A. (2006). Ensuring safe drinking water in Bangladesh. *Science*, 314(5806) 1687-1688.

[2] Bakker, K. (2008). The ambiguity of community: Debating alternatives to private sector provision of urban water supply. *Water Alternatives*, 1(2), 236.

[3] Baltazar, J., Briscoe, J., Mesola, V., Moe, C., Solon, F., Vanderslice, J., & Young, B. (1988). Can the case-control method be used to assess the impact of water supply and sanitation on diarrhea? A study in the Philippines. *Bulletin of the World Health Organization*, 66(5), 627.

[4] Båmstedt, U., & Skjoldal, H. R. (1976). Studies on the deep-water pelagic community of Korsfjorden, Western Norway: Adenosine phosphates and nucleic acids in Euchaeta norvegica (Copepoda) in relation to its life cycle. *Sarsia*, 60(1), 63-80.

[5] Bartram, J. (2009). Water safety plan manual: step-by-step risk management for drinking-water suppliers. World Health Organization.

[6] Bennett, D. (2012). Does clean water make you dirty? Water supply and sanitation in the Philippines. *Journal of Human Resources*, 47(1), 146-173.

[7] Bohm, R. A., Essenburg, T. J., & Fox, W. F. (1993). Sustainability of potable water services in the Philippines. *Water Resources Research*, 29(7), 1955-1963.

[8] Borrell, A., Garside, A., & Fukai, S. (1997). Improving efficiency of water use for irrigated rice in a semi-arid tropical environment. *Field Crops Research,* 52(3), 231-248.

[9] Duineveld, G. C. A., Lavaleye, M. S. S., & Berghuis, E. M. (2004). Particle flux and food supply to a seamount cold-water coral community (Galicia Bank, NW Spain). *Marine Ecology Progress Series,* 277, 13-23.

[10] Dyck, A., Exner, M., & Kramer, A. (2007). Experimental based experiences with the introduction of a water safety plan for a multi-located university clinic and its efficacy according to WHO recommendations. *BMC Public Health*, 7(1), 1.

[11] Esrey, S. A., Potash, J. B., Roberts, L., & Shiff, C. (1991). Effects of improved water supply and sanitation on ascariasis, diarrhoea, dracunculiasis, hookworm infection, schistosomiasis, and trachoma. *Bulletin of the World Health Organization,* 69(5), 609.

[12] Fawcett, P. (1998). Water safety education. *Strategies*, 12(1), 25-28.

[13] Ganiron Jr, T. U. (2016). Effectiveness and Impacts of Communal Irrigation Projects in Agriculture. *International Journal of Advanced Science and Technology,* 90, 61-70.

[14] Ganiron Jr, T. U. (2016). A Case Study of Site Conditions and Ground Stability of Town Homes. *International Journal of Smart Home,* 10(1), 207-216.

[15] Ganiron Jr, T. U. (2015). Towards Model Integrations of Tools and Techniques for Project Management Success. *International Journal of u-and e-Service, Science and Technology,* 8(7), 49-62.

[16] Kariuki, M., & Schwartz, J. (2005). Small-scale private service providers of water supply and electricity: A review of incidence, structure, pricing, and operating characteristics (Vol. 3727). World Bank Publications.

[17] Korten, F. (1982). Building national capacity to develop water users' associations: Experience from the Philippines. The World Bank.

[18] Krishna, A., Uphoff, N., & Esman, M. J. (1997). Reasons for hope: instructive experiences in rural development. Kumarian Press.

[19] Mälzer, H. J., Staben, N., Hein, A., & Merkel, W. (2010). Identification, assessment, and control of hazards in water supply: experiences from Water Safety Plan implementations in Germany. *Water Science and Technology,* 61(5), 1307-1315.

[20] Moe, C. L., Sobsey, M. D., Samsa, G. P., & Mesolo, V. (1991). Bacterial indicators of risk of diarrhoeal disease from drinking-water in the Philippines. *Bulletin of the World Health Organization*, 69(3), 305.

[21] Munasinghe, M. (1992). Water supply and environmental management: developing world applications. Westview Press.

[22] Nolan, B. T., & Hitt, K. J. (2006). Vulnerability of shallow groundwater and drinking-water wells to nitrate in the United States. *Environmental science & technology,* 40(24), 7834-7840.

[23] Sobsey, M. D. (2002). Managing water in the home: accelerated health gains from improved water supply. Geneva: World Health Organization.

[24] Summerill, C., Pollard, S. J., & Smith, J. A. (2010). The role of organizational culture and leadership in water safety plan implementation for improved risk management. *Science of the total environment*, 408(20), 4319-4327.

[25] Tabbal, D. F., Bouman, B. A. M., Bhuiyan, S. I., Sibayan, E. B., & Sattar, M. A. (2002). On-farm strategies for reducing water input in irrigated rice; case studies in the Philippines. *Agricultural Water Management*, 56(2), 93-112.

[26] Yoshioka, P. M., & Yoshioka, B. (1989). A multispecies, multiscale analysis of spatial pattern and its application to a shallow-water gorgonian community. *Marine ecology progress series. Oldendorf*, 54(3), 257-264.

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