



Harvesting and Managing Rainwater Using Collapsible Rubber Tanks

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Abstract

Rainwater harvesting (RWH) is an existing technology proven to be effective in reducing pressure on water resource, yet often overlooked by planners, engineers, builders and decision-makers as a viable alternative for supplying water to households and businesses while reducing stormwater runoff in urban settings. RWH tanks are commonly made of concrete, plastic, stainless steel, ferrocement or earthen jars. In this study, the use of collapsible rubber tanks (CRTs) as an alternative storage container for RWH was explored. The study was conducted in Barangay La Mesa, Calamba City, Philippines. This barangay uses rainwater for domestic use. Bladder or pillow, rectangular and square-type designs were installed, tested and monitored in terms of ease of use and handling. The portability of the tank makes it an attractive option in an urban setting where space is limited and land is expensive. A CRT with 500-800 liter capacity can be used by a five-member household for three days for their basic water needs, and comes at an affordable price range of PhP 3,500-5,000 (USD 65-95). With proper handling and maintenance, the CRT can be a good alternative for rainwater storage and serve other purposes. It can be useful in hard-to-reach areas particularly during emergency situations and relief operations.

Keywords: rainwater harvesting, collapsible rubber tank, climate change adaptation, El Niño

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Introduction

The Philippines is endowed with rich natural resources, including water. The average annual precipitation (amount of atmospheric moisture that fall back to earth by gravity) is about 2,348 mm. The total exploitable water resources are about 146 km³, 126 km³ of which is renewable surface water and 20 km³ is renewable groundwater (Food and Agriculture Organization [FAO], 2016).

Despite having these resources, accessibility to reliable and safe water supply remains a privilege not everyone can afford. Provision of water has been among the many problems constraining economic growth, good health, and overall development. In addition, water problems have become varied and complex; these include: inadequate surface water supply, over drafting of groundwater, flooding, sedimentation, pollution and degradation of drinking water (Klee, 1991).

Among the available water sources, groundwater has been highly exploited. In 2009, the country's total freshwater withdrawal was estimated to be 81,555 million cubic meters (MCM), of which 82% was for agricultural purposes (including 754 MCM of aquaculture, 8% of which is for domestic consumption and 10% is for the industry (FAO, 2012). With the current rate of groundwater utilization, more pressure is expected from the stressed resource, given the further increase in population and economic activities the country is experiencing. On one hand, voluminous rainfall tends to go to waste and its potential use is not maximized. During extreme rainfall, flooding may occur and can result in disastrous events. When this happens, the provision of sufficient amount of safe and potable water can be very difficult, thereby affecting hygiene and sanitation of stricken communities. The result can further lead to disease outbreaks of life-threatening cholera, typhoid, dysentery, and some forms of hepatitis.

The country also needs to prepare for the El Niño phenomenon, which is commonly associated with reduced rainfall that lead to dry spells, droughts, and stronger typhoons (FAO, 2017). Dry spells and drought are periods when rainfall is lower than the expected average amount over a longer period (World Meteorological Organization, 2006). According to the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), the latest El Niño to hit the country was in 2015-2016 and an estimated total damage and crop production loss of Php 4.7 billion (USD 87 million) was recorded.

These water-related problems are worsened by the impacts of climate change that lead to extreme events, and part of the plausible solution is harvesting and storing of rainwater. Rainwater harvesting (RWH)

captures, conveys, stores, and releases green water (the portion stored in soil and potentially available for uptake by plants) in-situ. Today, this technology has been proven effective in flood/disaster mitigation and aids in food and water security, environmental rehabilitation, and climate change adaptation. RWH, as a simple and stand-alone system, can be considered as one of the best practices in water resource management. In recognition, the country has enacted the Republic Act (RA) No. 6716 or the Rainwater Harvesting Act of 1989, which mandates the construction of water wells and rainwater collectors in all barangays¹. This RA is currently being revived by the Department of Public Works and Highways (DPWH). In 2009, Davao City passed a City Ordinance to reiterate proper harvesting, storage and utilization of rainwater. This ordinance sought to mainstream the use of RWH systems across the city. It also mandates that all new building construction should have provision for RWH.

Literature citing research work and undertakings on collecting rainwater for drinking purposes in the country are available, including those of Filipino inventor Dr. Antonio Mateo (Mateo, 2012). In Capiz Province, rainwater tanks were made of wire-framed ferrocement costing Php 3,500-6,500 (USD 67-125) for a 2-4 m³ tank. Before RWH was introduced in Capiz in 2002, households had the perennial problem of water scarcity during the six-month long dry season.

Common methods and types of collecting rainwater include the use of small impounding reservoirs. In residential areas, a more acceptable storage is the use of tanks. These tanks are mostly made of corrugated steel and enclosed metal, concrete, wood, fiberglass, clay, and polyethylene or polypropylene plastics. Such tanks are durable but rigid and require space. They can also be expensive unless recycled containers are used. In urban areas where space is cramped and limited, finding proper placement for these types of tanks can be difficult.

Such predicament gave rise to the idea of using a collapsible rubber tank (CRT), a geotextile fabric-made tank that is both flexible and foldable. The CRT, which has various uses for different conditions, could be the solution to a long-standing problem of water shortage. As a result, this research was conceptualized to specifically develop, fabricate and test various CRT designs, and influence water users and decision-makers to strongly support RWH.

¹ A barangay is a Filipino term referring to the smallest administrative division or village in the Philippines

Methodology

The research was conducted for one year and five months (June 2014 to October 2015) to adequately test the designed prototype during the rainy months. To test the effectiveness of the tank, prototype fabrications were installed in selected demonstration sites and responses were collected from 12 chosen participants.

Selection of Pilot Test Area and Cooperators

In pilot testing the applicability of CRT, an urban area was considered as an important criterion due to its high water demand and overly crowded and cramped residential spaces. Calamba City (Figure 1) was selected as the pilot site, being a center of trade in Laguna and in Southern Tagalog, and categorized as a highly urbanized area, thus with potential water deficit. Calamba is one of the most populous cities in the Philippines, with an average annual growth rate of 2.99% (2010 to 2015) and a total population of 454,486 (as of 2015). Demographic data and physical profile were gathered from different concerned offices, such as the Office of the City Planning, Office of the Engineering and Infrastructure Development Department, Calamba City Disaster Risk Reduction and Management Council (CDRRMC) and the Public Order and Safety Office (POSO).

It is worth-noting that during the ocular survey and preliminary inspection, it was observed that the residents were already practicing RWH with drums or plastic containers (Figure 2) because of inadequate supply of tap water.



Figure 1. Location map of Barangay La Mesa, Calamba City, Laguna

After selecting Barangay La Mesa, Calamba City as the demonstration area, meetings with the barangay officials and co-operators were undertaken to discuss the objectives and expected outputs of the research, and the role of each of the research partners. Research



Figure 2. The typical water storage are plastic drums and containers

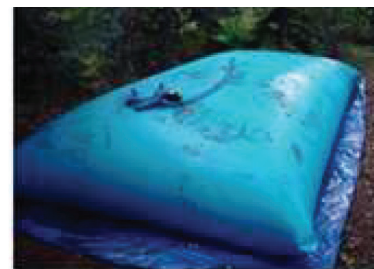
co-operators were selected using the following criteria: house has existing gutter and spout, and has space for CRT installation, and homeowner is willing to cooperate in data monitoring.

Design, Fabrication and Testing of CRTs

The tank designs for testing (bladder, pillow and square-type) (Figure 3) were initially patterned after existing collapsible tanks used in other countries.



(a)



(b)



(c)

Figure 3. Types of CRT designs: pillow or bladder (a and b); and vertical rectangular (c) (Waterplex, 2014; Portable Tanks, 2014; Interstate Products Inc., 2014)

The fabricated CRTs were tested and inspected for defects, such as leaks and tears, before installation. Modifications were later made to consider durability, ease of local fabrication, ease of use and handling, and ease of maintenance by the co-operators. While dependent on scale, the RWH system is relatively simple to use and potential users can easily be trained on how to install the tanks.

In determining the size of the CRT, information on average annual rainfall, roof catchment size, installation area, and water demand were necessary.

Annual Average Rainfall

This is the recorded and measured rainfall over an area. Records are usually available from PAGASA weather stations around the country. This information is necessary in computing for the potential available water to avoid oversizing the tanks. "As a general rule, rainfall should be over 50 mm/month for at least half a year or 300 mm/year (unless other sources are extremely scarce) to make RWH environmentally feasible" (Hattum & Worm, 2006). In the case of the Philippines, having an annual average rainfall of 2,400 mm provides an ideal condition for RWH.

Roof Catchment Size

It is the area of the roof for collection and discharge of rainwater. The roof should have gutters connected to a spout that will discharge to the tank.

Installation Area

It is the available area to install the tank. Ideally, the area should be accessible to the spout to minimize long gutter extension and to a canal/drainage/open land for discharge if rainwater will not be used.

Water Demand

It is the intended use of rainwater and water usage. In the Philippines, a person's average water consumption per day is 120 liters (The Philippine Environment Monitor, 2003).

Below is an example of how to compute for the potential available rainwater in a given area for a five-member family living in a building with a roof surface area of 100 m², and using the average annual rainfall in the area (e.g. Calamba City) of 2,400 mm, with a per capita consumption of 120 liters/day in an urban area:

Potential Available Water = Annual rainfall (in mm) x roof area (m²) x co-efficient of runoff from roof

Potential Available water

$$= \text{Area of catchment (A)} \times \text{annual rainfall (R)} \\ \times \text{Runoff Coefficient (C)} \\ = 100 \text{ m}^2 \times 2.4 \text{ m} \times 0.85 \\ = 204 \text{ m}^3 \text{ (204,000 liters)}$$

Water requirement per day

$$= \text{number of family members} \times \text{per capita requirement} \\ = 5 \times 120 \text{ liters/capita/day} = 600 \text{ liters day}$$

Based on this computation, a family of five will need approximately 3,000 liters for five-day duration of usage. A rainfall intensity of 53 mm/hr with T=2 years in a 1-hour rainfall duration can collect 5.3 m³ of water. Therefore, a 5,000 liter-capacity RWH tank can be easily filled up by a rainfall of 53 mm/hr intensity given a 100 m² roof area in less than an hour.

Estimated Runoff Volume

The surface runoff volume was computed using the Rational Method Equation: $Q_{\text{runoff}} = cIA$, where Q is the Peak discharge, c is the runoff coefficient (for roofs ranges from 0.75-0.95), I is the rainfall intensity, and A is the drainage area. This method is used to determine the peak discharge from drainage basin runoff. This was aided using ArcGIS software and images taken from Google Earth.

The water bill records of the selected 12 co-operators (Table 1) were gathered to determine the average amount of water consumption from the tap by each household. It is also the basis for computing their potential savings for using rainwater.

Table 1. List of co-operators from Barangay La Mesa, Calamba City

Cooperator	No. of household members	Water bill (PhP)
Cooperator 1	5	400
Cooperator 2	5	155 – 200
Cooperator 3	7	200 – 250
Cooperator 4	5	200 – 250
Cooperator 5	4	155 – 200
Cooperator 6	5	200 – 250
Cooperator 7	4	155 – 200
Cooperator 8	3	155 – 200
Cooperator 9	5	155 – 200
Cooperator 10	4	155 – 200
Cooperator 11	-	-
Cooperator 12	6	300

Monitoring and Evaluation

Regular visits, meetings, and focus group discussions were conducted to observe how the tanks were being used and maintained by the co-operators. These activities allowed the co-operators to immediately report to the research team the problems encountered in using the tanks. The number of interested adopters and inquiries were also recorded. Comparative cost analysis between CRTs and other types of rainwater storage tanks was also undertaken.

Results and Discussion

In general, water issues in Calamba City exist in various forms akin to other regions of the country. Access to water is not equal; some barangays have adequate supply all throughout the day, while others experience interrupted supply. Disparity can be observed more during the dry season, when no alternative source in the form of rain is available. Barangay La Mesa, the selected demonstration site in Calamba City, is one of those barangays with limited access to water.

A local cooperative is servicing the area for piped water supply. According to the residents, the tight water delivery schedule from the existing water utility forced them to look for alternative sources, one of which is the use of RWH containers. This is usually done during the rainy months, when rainfall is abundant. However, other parts of the city, especially those in the low-lying areas near Laguna Lake, experience flooding during the rainy days.

Potential Runoff Reduction by Rainwater Harvesting

The city's climate falls under Type 1, which has two pronounced seasons: dry from November to April

and wet during the rest of the year. Rainy months for Calamba City fall under June to September, and the average annual rainfall is 1,965.9 mm from 2000 to 2012 (Figure 4). Using Gumbel's theory of distribution, the computed maximum rainfall intensity is 305.86 mm/day for a rainfall event with a 24-hr duration and a 20-year return period. The data used in the computation came from PAGASA-Agrometeorological weather station in the University of the Philippines Los Baños (UPLB).

The estimated surface runoff for Barangay La Mesa was 264,473.33 m³/day. Currently, it has 2,545 households and a total population of 11,836. Assuming that the barangay would collect 10% of the total runoff, the amount of rainwater that could be harvested would have a volume of 26,447.33 m³/day.

Using the basic water requirement of 120 liters/capita/day (Philippine Environment Monitor, 2003), the volume of rainwater collected can sustain 220,394 people for a day. With this, the total population of Barangay La Mesa can be sustained for 18 days even without using the piped system. This was computed by dividing 264,473.33 m³/day by the population requirement of 1420.32 m³/day at 10% collection.

Using PAGASA's color-coded warning system and the area of each of the barangays in Calamba City, the amount of rainwater that could be collected was computed and summarized in Table 2 (next page). Assuming that all households, establishments, and facilities will install a RWH unit, runoff will be lessened and flooding can be delayed.

CRT Design Testing and Installation

Three designs were tested: the pillow type, the rectangular pillow type, and the vertical tank type (square-type). The first tank design tested for material strength and functionality was the pillow type (Figure 5), whose dimensions were as follows: height of 0.46 m., width of 1.52 m, and length of 2.13 m. The tank has inlet and outlet faucets, wherein the latter serves as a pressure control valve. The estimated average capacity of the tank is 1,100 liters. Once filled, the tank can be left to overflow to avoid the build-up of pressure, while leaks and defects found on the tank can be repaired using patches of similar fabric and a solvent for sticking. This design is suitable mostly to buildings and houses with large spaces, where it can be placed at the rear end or side of the house. With an approximate weight of 1.1 tons when filled with water, this type of large tank can be very heavy and would require a mechanized lifter

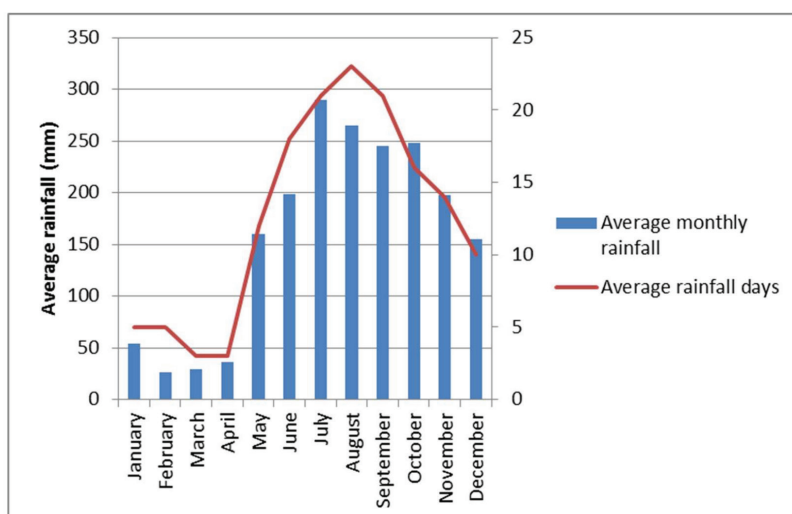


Figure 4. The average rainfall distribution in Calamba City from 2000 to 2012 (World Weather Online, 2015)

Table 2. Runoff estimate in the different barangays of Calamba City, Laguna using PAGASA's color-coded warning system

Barangay	# of household	Runoff estimate (m ³ /hr) for the next 3 hours		Barangay	# of household	Runoff estimate (m ³ /hr) for the next 3 hours	
		Yellow warning	Orange warning			Yellow warning	Orange warning
Bagong Kalsada	711	19093.5	38187	Mabato	152	25029	50058
Banadero	1530	23512.5	47025	Majada-Labas	1112	22675.5	45351
Banlic	1784	35316	70632	Makiling	1615	59193	118386
Barandal	995	23202	46404	Mapagong	1063	35892	71784
Barangay 1	1413	6961.5	13923	Masili	771	6286.5	12573
Barangay 2	1721	4239	8478	Maunong	453	35928	71856
Barangay 3	948	8307	16614	Mayapa	4693	19242	38484
Barangay 4	696	969.75	1939.5	Paciano Rizal	2571	20749.5	41499
Barangay 5	1351	4792.5	9585	Palingon	1377	3289.5	6579
Barangay 6	526	7407	14814	Palo-Alto	2285	28435.5	56871
Barangay 7	542	18274.5	36549	Pansol	2337	84379.5	168759
Batino	269	16065	32130	Parian	4354	14355	28710
Bubuyan	358	19665	39330	Prinza	859	15282	30564
Bucal	2440	44376.75	88753.5	Punta	755	42120	84240
Bunggo	819	51264	102528	Putting-Lupa	370	48780	97560
Burol	383	23800.5	47601	Real	2969	21253.5	42507
Camaligan	210	11452.5	22905	Saimsim	1184	23040	46080
Canlubang	11753	411921	823842	Sampiruhan	1751	16659	33318
Halang	1468	26221.5	52443	San Cristobal	2706	19957.5	39915

**Figure 5.** The pillow tank at full capacity

to transport to areas needing water. However, its high volume capacity is more practical for use in hard-to-reach areas in preparation for emergency and relief operations, but would have to be transported to intended evacuation centers when empty in order to ease the mobility.

The second design (Figure 6) was another rectangular pillow tank with the following dimensions: height of 0.19 m, length of 4.36 m, and width of 0.74 m. The

**Figure 6.** Filling of rectangular pillow tank (left); Pressure valve releasing excess water from the tank (right)

estimated capacity of the tank is 600 liters. In addition to the inlet and faucet, a water release outlet was added to the tank to avoid overfilling that may result in tearing. Similar to the pillow tank, it can be used for various purposes in different types of housing and building structures. However, it proved to be more difficult to balance during transport, especially when filled with water, and finding a space for this type is more laborious due to its longer length.

The third design is a square-type tank (Figure 7) with the following dimensions: height of 1.83 m and square base of 0.76 m with an estimated capacity of

1,057 liters. One problem encountered with this type is its inability to support itself when filled with water. While the size can be reduced to achieve its form and serve its purpose with minimal difficulty in handling, a better option would be to provide a frame to support its body (Figure 7a).

The vertical rectangular type (Figure 7b), with a dimension of 1.22 m in height, 0.7 m in length and a width of 0.46 m, was also tested. The estimated capacity of the tank is 300 liters. It is smaller than the square-type but with similar need in terms of support. To address this, a metal casing was also fabricated to support the tank, which added cost to the production. In the design and fabrication of CRT, economic viability and flexibility were important considerations.



Figure 7. Testing of (a) vertical square-type tank and (b) vertical rectangular type tank

The fabrication of CRT was customized for the individual co-operator. Table 3 shows the locally fabricated CRTs installed in the field. These tanks (Figure 8), excluding the vertical tank, need a simple stand for a more convenient water withdrawal.

Material and Fabrication

Flexible bladder tanks are made with high-resistance, waterproof polyvinyl chloride (PVC) material, similar to that of rubber boots (Figure 9) and are welded with high frequency (HF) soldering techniques. It



Figure 8. Common types of tanks tested in the site were bladder and square-type CRT



Figure 9. Common materials for making the tank include high resistance PVC e CRT

Table 3. Type of installed CRTs in the field (refer to Figures 6-8 for the sample prototypes)

Tank type	Dimension (empty) L x W x H	Dimension (filled) L x W x H	Capacity	Units	Cost (P)
Water-bed type 1	1.52 x 0.61 x 0.45	1.75 x 0.9 x 0.46	750	9	3,500
Water-bed type 2	1.83 x 0.61 x 0.45	2.00 x 0.9 x 0.46	810	4	3,800
Square-type	1.10 x 1.10 x 0.40	1.34 x 1.34 x 0.46	820	1	5,000

is important that the seam can withstand the water pressure. Repeated testing and modification of the design and process eventually resulted in a tank that can withstand water pressure and resist bursting. However, continuous improvement of the design and materials used should be done for the technology to have a competitive commercial advantage.

Tank Components, Installation and Mobility

The tank has an inlet, a faucet, and a pressure release hole/valve through which water can automatically spill out when the tank reaches full capacity. Since

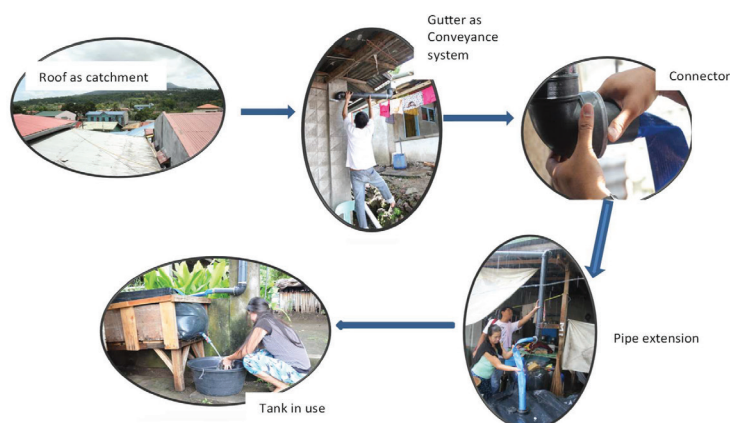


Figure 10. Schematic diagram of CRT installation

the tank is made of a geomembrane textile material, it can be easily installed (Figure 10) or dismantled for safekeeping when not needed. The CRT may be placed in any unused or vacant space, such as at the basement, roof of the house, or under any structure near a spout. The CRT can be considered as the new-generation tank.

Before installation, gutters and spouts must be inspected to ensure they are properly connected to the roof. Simple measures should be observed and followed, which include:

1. Collapsible water tanks should be water-tight and should be placed in a containment structure (for vertical tank) or a ground mat (for horizontal tank) for support and protection.
2. The tank should be placed in a leveled area, free from materials that may damage the tank. It must be placed in a location allowing easy access for maintenance. Lastly, the tank should be placed near a canal or open land for drainage or recharge, in case the collected water will not be used.
3. The tank should be labeled with "RAINWATER" to inform that it contains rainwater and is not suitable for drinking.
4. When rainfall intensity is high and water is expected to overflow, the pressure release valve should be opened to prevent overfilling the tank.
5. Rainwater entering the CRT must pass through a

filtering mechanism (e.g. screen) to prevent entry of debris into the tank. Gutters should be cleaned out once in a while to reduce debris accumulation and spout clogging.

6. Roof and gutters should be repaired if there are any damages. Roof material should not be made from asbestos or wood, and painted with substances harmful to human.
7. Branches extending above the roof should be pruned.



Figure 11. A wooden stand is an optional feature to elevate and secure the tank

Tank Frame or Stand

As seen in Figure 8, placing tanks on the ground causes difficulty in fetching water due to its low elevation, which hinders water from flowing freely. Depending on the user's preference, a stand may be needed to elevate the tank, of which any design may be used as long as it can securely hold the tank. On the other hand, a frame is optional (Figure 11).

Monitoring Process

Twelve tanks were installed and monitored in the research area. Weekly monitoring to assess the functionality, ease of use, and manageability of the tanks was also an important step, wherein the problems that were encountered, such as leaks, were timely resolved.



Figure 12. One of the co-operators filling the tank with rainwater

The co-operators were able to continuously fill the tanks during the rainy months (Figure 12). According to the users, the tank with a capacity of at least 700 liters could be filled to its maximum in less than 2 hours, given an average rainfall of 204.70 mm/month. The rainwater collected in the CRT was used primarily for laundry, flushing, cleaning of the house, watering of plants, and washing of vehicles. One account from the co-operators said that their average monthly bill of around PhP 400 to PhP 550 was reduced to PhP 300, and their dependence on water utility was lessened.

When asked whether they would still use the CRT if available commercially, the co-operators gave a generally favorable and positive response. To further improve the tank's lifespan, which was an observable limitation, discussions on proper maintenance were mentioned.

Economic Considerations

The cost of the locally fabricated CRT with a minimum capacity of 600 liters ranges from PhP 3,500-5,000 (mat and frame not yet included). According to a hardware, the price of a stainless steel tank with a capacity of 800-1,000 liters is between PhP 15,000-19,000, while the price of a polyethylene tank with a capacity of 600 liters is at least PhP 8,200. The fabrication cost of CRT is cheaper compared to the cost of rigid tanks. However, proper comparison in terms of life span and durability cannot be concluded yet, as the locally fabricated CRT is still under test and research. However, it can be noted that rigid tanks can be used from 8 to 14 years and based on the experiences of long-time users abroad, CRTs have a warranty of approximately 5 years (Portable Tanks, 2014). It is important to consider certain factors that affect the lifespan of a tank, mainly: fabrication materials, application, environment, and external influences such as temperature and exposure to heat.

The recommended average water use in the Philippines is 120 liters/capita/day (Philippines Environment Monitor, 2003). Assuming that the average number of household members is five, the monthly consumption of a household is 18,000 liters or 18 m³ on the average. The cost of the first 10 m³ is PhP 183 and PhP 19.20/m³ for the succeeding 10 m³. The water consumption cost is PhP 336.60 (2% tax included). With this current water rate in Calamba City, monetary savings from using the collapsible tank is minimal. However, continuously drawing underground water for consumption and utilization can lead to its depletion, which poses a problem. In Australia, the government gives rebates to their residents when using RWH tanks to lessen dependency on groundwater.

Minimizing the Effects of Drought

The country has experienced one of the most severe

El Niño phenomena on record in late 2015 to June 2016. Another incident was in 1998, when 70 % of the country was affected and PhP 3 billion (USD 56.9 million) (Rodrigo, 2016) worth of crops were damaged. In such instances, the agricultural sector took a serious hit, which led to low production of staple crops such as rice. The reduced rainfall did not only lead to dry spells and droughts, but the phenomenon also resulted in stronger typhoons. While El Niño is to be expected, with sufficient planning and support, its effects can be minimized. Before the onset of the dry season or drought event, rainwater can be collected and stored in tanks and can serve as water source for household use and other purposes whenever there is lack of water supply on dry days.

Other Observed and Realized Benefits

The residents of Barangay La Mesa, Calamba City were using RWH to augment the water supply from the local water utility. They use any available container to store rainwater, but the rising dengue cases in the area prompted the officials to prohibit rainwater collection using containers without cover. Since the CRT is covered, entry of dengue-carrier mosquitoes was prevented and breeding in the tanks was reduced, if not stopped. As a result, the project was endorsed by the barangay officials and the pilot-testing of the CRT in the area was readily welcomed by the residents as an alternative to their usual water containers.

Overall, the CRT has a very good potential for rainwater storage, whether it be in drought-stricken or flood-prone urban areas. This can be attested by the increasing number of invitations from various local governments units for seminar on CRT.

Conclusion and Recommendations

Using CRT for harvesting rainwater is a newly explored endeavor. The CRT has high potential for wider use and commercialization, especially in a tropical country like the Philippines, where occurrences of drought, flooding and tropical diseases associated with stagnant water are common. Wider dissemination and adoption of this type of technology should be supported, along with continuous improvement through research and partnership with an industry capable of fabricating the CRT. This will ensure a design that will be commercially available and affordable for ordinary citizens. Moreover, policy support and advocacy to strengthen and mandate RWH for sustainable water supply should be implemented and adopted. The case of the DPWH reviving and revisiting RA 6716 mandating the development of rainwater collectors is a good initiative in showcasing water conservation in the Philippines. Through this effort, total reliance on water utility systems for all types of water demand can be minimized, if not totally avoided, which can

then lessen the continuous usage and depletion of groundwater to give it time to recharge. Moreover, adoption of RWH can also prevent or delay flooding.

While the pilot-testing of fabricated CRTs have demonstrated good acceptability among the co-operators, continuous improvement on the following should be done:

- tank design
- durability
- use of locally available materials
- filtration system
- water quality assessment and
- application in agriculture, emergency and relief operations

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