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Flooding Resiliency of Surigao del Sur, Caraga Region, Philippines Residences Through Rainwater Catchment and Storage System

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ABSTRACT

Urbanised areas in Northeastern Mindanao have a problem of addressing flooding occurrences. This study primarily aimed to provide insights into how the rainwater catchment system of uptown communities and their cooperation could increase flood resiliency of downtown communities in the Surigao del Sur, Caraga Region, Philippines. This research employed quantitative analysis of the eleven (11) year (2010-2020) data from the Philippine Atmospheric, Geophysical, and Astronomical Services Administration - Hinatuan, Surigao del Sur station. The recommendable optimum rainwater storage capacities for a given number of household occupants, roof areas at run-off efficiency of 90%, and three (3) day rainfall characteristics at 36.9% averaged probability of exceedance were initially determined. Through scenario analysis, uptown communities emptying their rainwater storages before heavy downpour occurs could provide sufficient flood volume reduction and buffer time for downtown communities to prepare. The output of this research is vital in the environmental planning, management, and policies of cities and regions.

INTRODUCTION

Human life was never out of challenges. Disasters disturb natural, constructed, and social environments, affecting communities and people. They can be caused by climatic, geophysical, technical, or human-caused events, or a mix of these (Liu et al., 2018; McCoy et al., 2014; Bourque, et al., 2007). A database was created from 1970 until 1999 to estimate the hazard of life from Atlantic tropical storms in the

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contiguous United States and surrounding coastal seas (Rappaport, 2000). During those thirty (30) years, freshwater floods were responsible for more than half of the six hundred (600) deaths in the United States caused directly by tropical storms or their remnants, with most deaths occurring in inland counties (Rappaport, 2000). The flood deaths that are most easily identifiable are those that occur as a result of drowning or trauma, such as being struck by items in fast-flowing waters (Adikari et al., 2010; Ahern et al., 2005; Jonkman & Kelman, 2005). Bernard et al. (2001) explained that because of the increased overall water volume, rapid water flow rates, and a limited warning period in which to seek refuge, flash floods caused by massive rainfalls in short intervals are the deadliest. Studying and anticipating how global climate change may impact severe rainfall, flooding frequency, and size (Schumacher, 2017). With good disaster conditions and a lack of preparation and mitigation, disaster is just around the corner, ready to strike (Khaerani, 2022).

Because of its location, typhoons, tropical depressions, and persistent heavy rainfall (B. Racoma et al., 2021) are the most common causes of flooding in the Philippines (Corporal-Lodangco & Leslie, 2016). Since the mid-twentieth (20th) century, the country's extreme rainfall intensity and frequency have risen, and tropical storms and cyclones—often accompanied by storm surges, strong winds, flooding, and landslides—have produced fatal and expensive disasters (Yonson, 2019; Cinco et al., 2016; Franta et al., 2016). Furthermore, climate models suggest that precipitation would (continue to) drop in the dry season while increasing in the rainy season until mid-century, increasing the risk of flooding and landslides (Tubog et al., 2023; Cabrera & Lee, 2018; Froude & Petley, 2018).

Human activities are related to these problems. It has been known that urbanisation has caused detrimental effects on the environment (Johnson et al., 2020; Wang et al., 2019; Newman, 2006) especially on vegetation (Brandalise et al., 2019; De Carvalho & Szlafsztein, 2019; Guan et al., 2019; National Disaster Risk Reduction and Management Council (NDRRMC), 2015; Pandey & Seto, 2015) eventually leading to increased flood risks (Mahmoud & Gan, 2018; Chen et al., 2015; Li et al., 2013; Zhang et al., 2008). Along with it, the informal settlers' expansion and a lack of tenure have also pushed many to squat in marginal and hazard-prone places such as flood-prone zones, riverbanks, along the seashore, and on steep hillsides, making them exposed to natural hazards such as flooding (Swiss NGO DRR, 2014). In addition, bronchitis, respiratory tract infection, influenza, chickenpox, measles, typhoid fever, diarrhoea, leptospirosis, dengue fever, hypertension, and heart disease are all linked to one or more of the flood variables: exposure, height, or duration (Okaka & Odhiambo, 2018; Yonson, 2018). This also causes flood-related diseases, costing the government a lot of money and putting a lot of strain on afflicted families, pushing non-poor households into poverty (Jha et al., 2018) and the marginalised further into poverty (Yonson, 2018; Torti, 2012).

Government investment in infrastructures alongside sustainable policy direction plays a critical part in protecting the welfare of urban and rural residents. An example is the building flood mitigation structures which contributed to society's flood mitigation efforts have been thoroughly researched and improved throughout the years (Madden et al., 2023; ; Basack et al., 2022; Nurjanah & Apriliani, 2021; Starominski-Uehara, 2020; Sayers et al., 2013; de Bruijn, 2004). However, community resilience is not solely a government responsibility but also involves the active engagement and participation of the community members themselves (Shi et al., 2022; Pramudita & Nugroho, 2021; Sulaiman et al., 2019; Vårheim et al., 2018; Zamboni, 2017). While researchers (Fewkes & Warm, 2000; Alfonso et al., 2019; Chang et al., 2018; Gerolin et al., 2010; Jameson & Baud, 2016; Vaes & Berlamont, 2001) have already justified the use of household rainwater harvesting systems to help buffer flood occurrence, only few contextualised it in the Philippines as part of countermeasures to flooding were made (A Oraya, 2023; Ching Tan, 2023; Bañados & Quijano, 2022). Finding the optimum storage tank sizes in the context of local climatic conditions is still challenging (A Oraya, 2023).

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This study aimed to optimise the sizing of rainwater tank storage for housing development concerning its climate type. For this case, Surigao del Sur, Philippines, has a Type II climate defined as a no-dry season with a very pronounced maximum rain period from November to January (DOST- PAG-ASA, n.d.). Furthermore, this intended to do one of its functionalities – simulating the reduction of flood and providing an efficient buffer period based on the capacity of rainwater tanks to harvest rainwater. The outcome of this study shall enable us to formulate policies that can add to the body of knowledge and alter social behaviours in responding to the call for risk reduction.

LITERATURE REVIEW

A community manifesting resiliency meets the Sustainable Development Goal (SDG) of sustainable cities and communities (SDG 11), contributing to the disaster mitigation efforts of the locality and the country. A resilient community also gathers and reserves the financial resources needed from a variety of sources, including national capital markets, for climate change mitigation and adaptation initiatives, as well as response and reconstruction in the event of natural disasters, particularly earthquakes, floods, and storm surges that are endemic to the East Asia Region (Costa et al., 2016). Resiliency becomes evident during disastrous and hazardous events, especially during floods. Floods are the natural hazard with the highest frequency and the widest geographical distribution worldwide (United Nations, 2021; World Meteorological Organization, 2021; CRED, 2019; Chandrappa et al., 2011). Flood hazards continuously disrupt human living conditions globally, so flood resiliency became a framework for risk reduction in water-related disasters (Liao, 2012). To better understand the concept of resiliency in this study, the author anchored on Brujin's (2004) definition of resilience as the ability of a system to maintain its most important processes and characteristics when subjected to disturbances. Systems may be about engineering, ecological, or socio ecological. Specifically, Zevenbergen et al. (2020) classified engineering resilience as an outcome that relies on the design, adaptation, construction, and deployment of flood-resilient technologies and structures in reducing the recovery time after failure, consequences during failure by floodwater and the probability of failure focusing on flood hazard mitigation.

Interagency Efforts

The Philippines is one of the most vulnerable countries in Southeast Asia, continuously being at risk of floods (Noor & Maulud, 2022; Thomalla et al., 2017). Heavy rainfall and precipitation caused by weather systems contribute to minor and major flooding incidents in the country. Recently, the Philippines reported that floods damaged two hundred and ninety-three (293) houses due to Southwest Monsoon rains (European Civil Protection and Humanitarian Aid Operations, 2021). Continued interagency efforts have mitigated flood casualties and damages in the country through flood advisories, warnings, and bulletins. The National Disaster Risk Reduction and Management Council (NDRRMC), with the Office of Civil Defense (OCD) as its implementing arm, serves as the main frontline in informing and responding to the local government units (LGU). NDRRMC communicates and collaborates with the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA) and the Department of Public Works and Highways (DPWH) in exercising flood management (Unite, 2021). It operates under the National Disaster Risk Reduction and Management Framework (NDRRMF), which anchors the National Disaster Response Plan (NDRP). At present, the NDRP expects all LGUs to have emergency plans for Hydro-Meteorological Hazards (typhoons, monsoons, low-pressure areas, flooding, storm surge, and rain-induced landslides) along with their Local Disaster Risk Reduction and Management Plans (LDRRMPs) in place (Alcantara & Christopher, 2019).

Before NDRRMC was implemented through the Philippine Disaster Risk Reduction and Management Act of 2010, the Republic Act 6716 (RA), known as the Rainwater Collection and Springs Development Law of 1989, was promulgated. RA 6716 seeks to provide for the Department of Public Works and

Highways' (DPWH) construction of water wells and rainwater collectors, the development of springs, and the rehabilitation of existing water wells in all barangays in the Philippines.

Rainwater Harvesting Systems for Flood Reduction

Rainwater harvesting (RWH) is an engineering method known for collecting water from storms and rainfalls (Jamali et al., 2020; Semaan et al., 2020; Farreny et al., 2011; Imteaz et al., 2011; Helmreich & Horn, 2009). However, the practice of RWH is not limited to the collection of water alone but also poses several advantages, which include mitigating flood and enabling environment-friendly engineering design (Vojinovic et al., 2021; Jamali et al., 2020; World Bank, 2019; Teston et al., 2018; Melville-Shreeve et al., 2016; Burns et al., 2010). These advantages motivated countries to the scientific design of cost-effective and highly efficient rainwater harvesting systems, which ensures sustainability and efficiency in supplying water and maintaining urban structures during heavy rainfall events (Pelak & Porporato, 2016; Chiu et al., 2015; Matos et al., 2013; Esguerra et al., 2011; Roebuck et al., 2011). Over the years, installing rainwater harvesting technologies to mitigate floods has continued to be a subject of scientific inquiry.

There were contrasting views. It was stressed that RWH mainstream techniques can only mitigate slight rain (Qin, 2020; Mentens et al., 2006). Another case study by Kim & Yoo (2009) simulated that the flood reduction effect is estimated to be only 1% when using 10% of the entire city area as the rainwater collecting surface. On the flip side, some posited (Alfonso et al., 2019; Chang et al., 2018; Jameson & Baud, 2016; Gerolin et al., 2010; Vaes & Berlamont, 2001; Fewkes & Warm, 2000) that indeed rainwater promoting rainwater harvesting systems to significantly reduced flood incidence. Freni & Liuzzo (2019) concluded that RWH systems are essential in lowering flood volumes and averting potential drainage system breakdowns during storm events, and in flooded regions, they can be decreased by up to 100% during minor rainfall events. A rainfall event with a depth of up to 50 mm might result in a 35% reduction in a flooded area. For heavy rainfall events, the reduction in inundated areas is minimal. In the Philippines, Borgonia & Fornis (2020) simulated a rooftop rainwater harvesting system in Mandaue City and reported that flood volume reduced from 6.03% to 15.27%. Most literature emphasised the efficiency of rainwater harvesting systems on flood reduction in urban areas while decreasing efficiencies during heavy or severe rainfalls (Borgonia & Fornis, 2020; Qin, 2020; Mentens et al., 2006) have been observed. In any case, both sides scientifically explored avenues to explain its effectiveness and efficiency.

However, urban residences have different topographies from the countryside. There is significant uncertainty regarding contextualised quantitative comparisons of how much rainfall volume is observed from one region to the other. Furthermore, most methodologies used in determining storage sizes were weekly (Xu et al., 2020) or monthly rainfall data (Nguyen & Han, 2017; Imteaz et al., 2012), which may not be relevant in Type II Climate areas. Through these gaps, the researchers are optimistic about obtaining significant results.

METHODOLOGY

Precipitation Data

The initial objective of this research is to recommend storage capacities that apply to different factors. Researchers (Matos et al., 2013; Imteaz et al.,2010; Khastagir & Jayasuriya, 2010) evaluated the dependability of rainwater tanks or storage under several scenarios, including climatic conditions, roof areas, tank sizes, household water needs, and the percentage of total demand met by rainwater. Recorded precipitation is vital in the analysis (Nguyen et al., 2018; Furumai, 2016; Matos et al., 2013; Moruzzi et al., 2012; Imteaz et al., 2011; Islam et al., 2011; Khastagir & Jayasuriya, 2010; Pachpute et al., 2009).

The climatic conditions of this study were based on eleven (11) years (2010 to 2020) of rainfall data gathered from the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAG-

ASA) Surigao del Sur, Caraga Region. Because it does not rain every day, this research recommended considering the three (3) day accumulation. Thus, calculating the average accumulated three (3) day rainfall for the eleven (11) years recorded yields the equation.

$$RainfallAve_i = \frac{1}{N}\sum_{j=2010}^{2020} x_j \qquad (1)$$

where, x_j is the three (3) days of accumulated rain for the year j, and N is the number of years (11 years).

Probability of Exceedance

Thomas and Martinson (2007) expressed that sizing rainwater storage is accompanied by roughly 30% uncertainties due to the generalisation of precipitation data from different locations. Rainwater catchment and storage system design should be based on estimations of rainfall depths that can be predicted with varying probabilities or return periods rather than the long-term rainfall data average because rainfall varies over time (Dirk, 2013). The statistical probability, also known as the probability of exceedance, refers to the likelihood that actual rainfall will be equal to or greater than the expected rainfall depth over time (Dirk, 2013). The likelihood of exceedance, Px, of the eleven (11) year three (3) day rainfall data as explained below using statistical tool regression coefficients.

$$P_x = Ae^{-Bx}+P_0 \qquad (2)$$

where x is the three (3) day rain inputs. Every averaged three (3) day data distributed over the year has a certain chance of exceeding. The rainfall depths may then be estimated using the mean probability of exceedance.

The three (3) day rainfall run-off is computed using the following equation to determine the harvestable rain, RR (Khastagir et al., 2010; Khastagir & Jayasuriya, 2009)

$$RR = R_{eff}\times C_R\times A \qquad (3)$$

where R_{eff} is the three (3) day rain volume per unit area (m^3/m^2) at the calculated probability of exceedance, C_R is the constant of run-off, and A is the roof area coupled to the tank (m^2). The constant of run-off used was 0.90 for smooth and impervious surfaces (Kinkade-Levario, 2007).

Water Demand/Requirement

Since rainfall data is on hand and the demand for the analysis daily, it would be justifiable to be consistent with the daily use of time (Xu et al., 2020; Freni & Liuzzo, 2019; Zhang & Hu, 2014; Burns et al., 2010; Kim & Yoo, 2009). Daily water consumption per capita was used to determine rainwater tanks. This paper was simulated based on the number of consumers according to water demand and the average water utilisation. When a lengthy rainfall time series is used to simulate the demand as a continuous drawdown, knowing the daily variance of the household's water use is of minimal relevance (Vaes & Berlamont, 2001; Fewkes & Warm, 2000). Researchers (Freni & Liuzzo, 2019; Nguyen et al., 2018; Lopes et al., 2017; Campisano & Modica, 2012; Ghisi, 2010) used two (2) to five (5) numbers of residents per household. With the average household size in the Philippines in 2020 being 4.4 people per household (ESRI, 2013), this research used the range from two (2) to five (5) people per household.

Rainwater Tank Optimisation

Determining optimal rainwater tanks entails many benefits in rural residences involving efficient collection and installation. This research followed the methods of Nguyen & Han (2017) in optimising the sizes of rainwater tanks with modifications in the variables. A simple rainwater harvesting, and storage system comprises a rooftop, downpipe, first flush, storage tank, water supply, and overflow (see Figure 1 below).

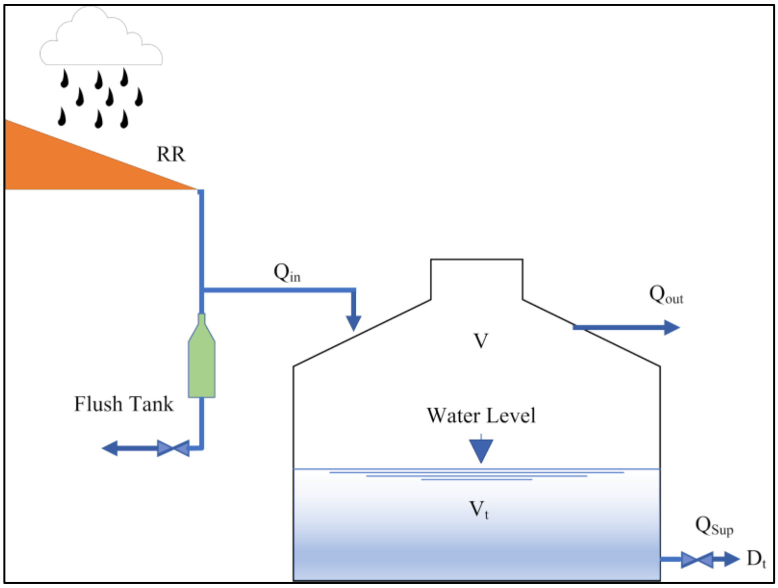

Fig. 1. Simple Rainwater Harvesting and Storage System

Sources: Authors, 2023

Initially, simulation of the water flow (equation 4) in a rainwater tank as a precursor in determining the water balance (equation 5) with the following:

$$Q_{in,t} = R_{eff} \times A \times C_R \times 0.001 = RR \times 0.001 \tag{4}$$

$$V_t = V_{t-1} + Q_{in,t}\Delta t - Q_{out,t}\Delta t - Q_{sup,t}\Delta t \tag{5}$$

where:

$Q_{in,t}$ is the inflow rate into the rainwater tank (m^3/three (3) day) at time *t* and is the same as the run-off flow rate from the roof in three (3) days;

V_t is the cumulative water stored in the tank (m^3) at time t;

V_{t-1} is the cumulative water stored in the tank (m^3) at time t-1;

Δt is the time increment (three (3) day);

$Q_{sup,t}$ is the water supply rate from the rainwater tank (m^3/three (3) day) at time t; and

$Q_{out,t}\Delta t$ is the overflow rate from the tank (m^3/three (3) day) at time t.

$Q_{sup,t}$ and $Q_{out,t}$ can be mathematically described as follows:

if $V_t \leq 0 \rightarrow Q_{sup,t} = 0$; and

if $V_t > 0$, the water supply is limited by the cumulative water stored and inflow quantity in the tank.

$$V_{t-1} + Q_{in,t}\Delta t < D_t\Delta t \rightarrow Q_{sup,t}\Delta t = V_{t-1} + Q_{in,t}\Delta t \tag{6}$$

$$V_{t-1} + Q_{in,t}\Delta t \geq D_t\Delta t \rightarrow Q_{sup,t} = D_t \tag{7}$$

where:

D_t is the water demand (m^3/day) based on the product of average water consumption with an average estimate of hundred and fifthly (150) litres per capita per day for personal hygiene, sanitation, laundry, and kitchen activities (Andres & Loretero, 2021; Berwanger & Ghisi, 2018), and the number of household members.

If $V_t \leq V \rightarrow Q_{out,t} = 0$

where V is the full capacity volume of the storage tank.

If $V_t > V$ the tank is full

$$Q_{out,t}\Delta t = V_{t-1} - V + Q_{in,t}\Delta t - Q_{sup,t}\Delta t \tag{8}$$

The analyses provided the basis for the optimisation of rainwater tanks; a high water-saving value indicates that higher tap water can be saved by using rainwater and is mathematically described as:

$$\textit{Water Saving} = \sum Q_{sup,t}\Delta t \tag{9}$$

The above discussion is presented in Figure 2 below in the yearly (T_{sim}) simulation algorithm.

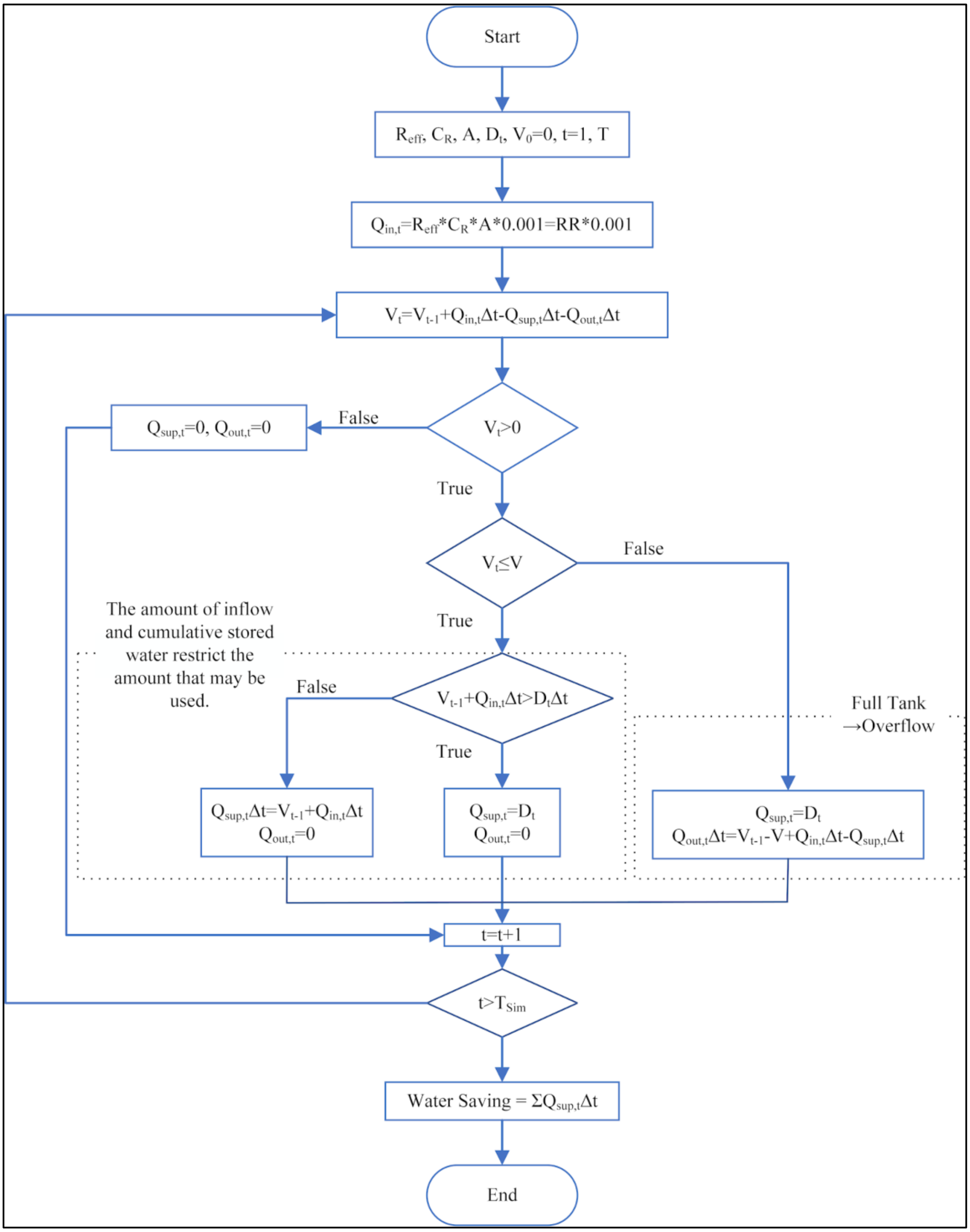

Fig. 2. Water Balance Algorithm

Sources: Authors, 2023

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This study collected daily rainfall data for Surigao del Sur, Caraga (Region 13), Philippines. The rainfall data were analysed with a 36.9% average probability of exceedance. A typical roof area range was quantified conservatively (Figure 1), and a range of tank sizes ranging from 0.5 to 3 m^3 was considered. In equation 1, 0.9 is a constant value based on the estimated run-off efficiencies considering smooth, impervious surface joints in residential houses in the Surigao del Sur, Caraga region (Region 13). Combined variables were identified in estimating optimal rainwater tank storage, roof area, and household water demand. Optimal value was accomplished when a curve's values begin to saturate, demonstrating less returns in progress (Bayoumy, et. al., 2020; Mahmoudi & Feylizadeh, 2018; Kubanek, 2017).

Table 1. Simulation parameters in determining optimal rainwater tank storage

Variables	Range of Values
A	1 - 200 m^2
S (water storage capacity)	0.5 - 3 m^3
D_t	150 liters per capita

Sources: Authors, 2023

Flood Reduction and Time Buffer Simulation

The rainwater harvesting systems are essential in reducing flood volumes and averting potential drainage system breakdowns during storm events. Nonetheless, the magnitude of rainfall impacts these systems' efficacy (Freni & Liuzzo, 2019). Various studies used different rain classifications (Golz et al., 2016; Lu et al., 2021; Langousis & Veneziano, 2007). The PAG-ASA (n.d.) have quantitative values starting from very light rains (exposed surfaces do not get wet irrespective of duration), light rains (rate of fall: from trace to 2.5 mm per hour), moderate rains (rate of fall: from 2.5 to 7.5 mm per hour), and heavy rains (rate of fall: greater than 7.5 mm per hour). This study's simulation was based on 15, 30, 45, and 60 millimetres per hour of rainfall intensity.

Flood buffers were analysed utilising the transposed no-water day. In the same analogy of pre-releasing waters as a significant dam management strategy in reducing flood impact (Ishak & Hashim, 2018; Ahmed & Mays, 2013; Chen et al., 2012; Huang & Hsieh, 2010; Valeriano et al., 2010; Viseu & Almeida, 2009), rainwater storages, especially from uptown urban areas, maybe emptied before heavy rains and storms. It can be mathematically expressed as:

$$T_{buff} = V \div Q_{in,t} \tag{10}$$

where:

T_{buff} is the buffer or the time duration to fill the water tanks;

V is the tank volume;

$Q_{in,t}$ is the inflow rate.

DISCUSSIONS

Findings revealed that the calculated probability of exceedance ranges between 15.54% and 50% in each three (3) day of a year, as presented in Fig. 3 below. Its average is 36.9% (R^2=0.977), and integrating it to the yearly three (3) day accumulated rain depth and run-off coefficient of 90% is illustrated in Figure 4, showing the harvestable rain, RR, when multiplied by the roof area.

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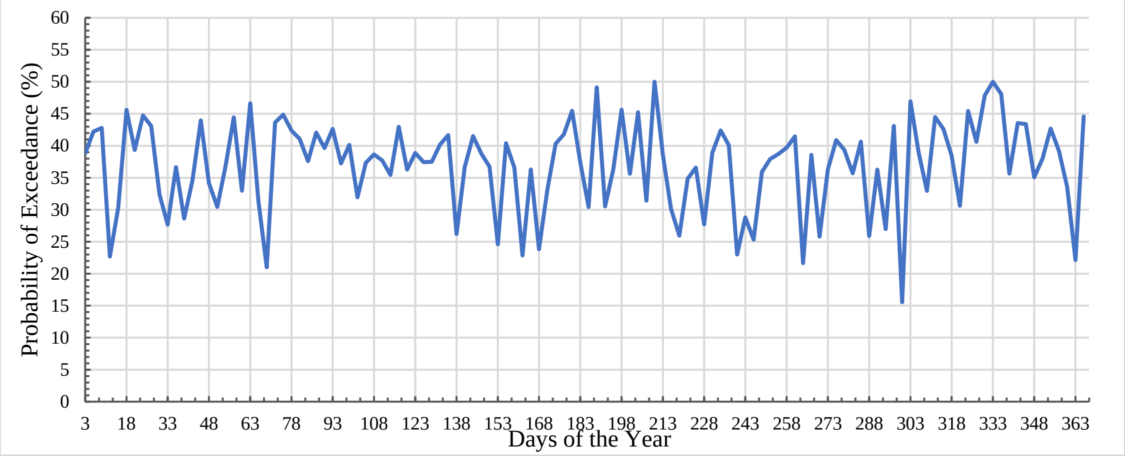

Fig. 3. Probability of Exceedance

Sources: Authors, 2023

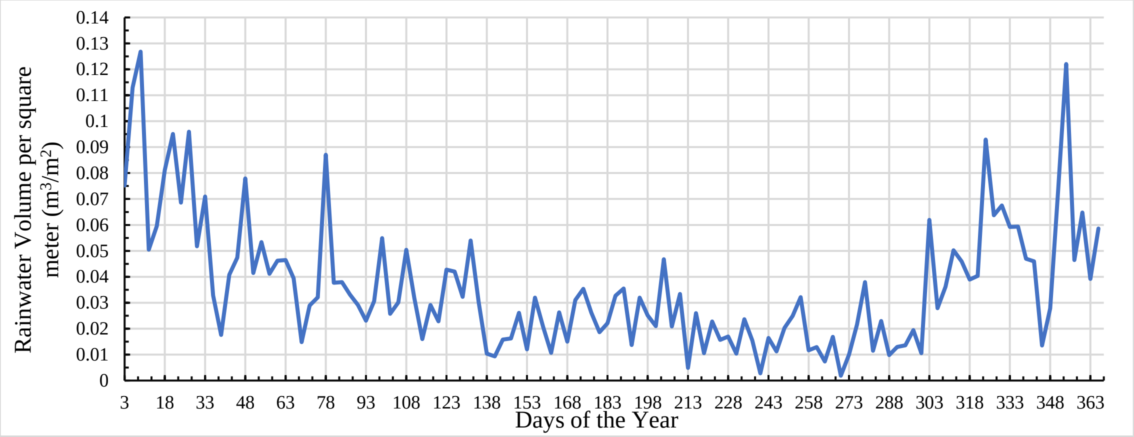

Fig. 4. Three (3) day rainfall volume per unit area collected with 90% run-off efficiency with a 36.9% probability of exceedance in Surigao del Sur, Caraga Region Philippines

Sources: Authors, 2023

Figure 5 below illustrates the yearly three (3) day water-saving characteristics of tank sizes S0.5 (black=0.5 m^3), S1 (red=1m^3), S2 (blue=2m^3), and S3 (green=3m^3) plotted on various roof areas (0.9 run-off factor) concerning the number of household users H2 (2 persons), H3 (3 persons), H4 (4 persons), and H5 (5 persons). Optimum sizes also vary depending on the number of consumers per household. For H2, the savings are steeped on roof areas within the range of 0 m^2 to 15 m^2 until the curve bends and gets less efficient until its benefit ceases on areas between 70 m^2 to 80 m^2. H3 has optimum benefits with 0 m^2 to 20 m^2 and less beneficial onwards until all tank sizes would only have minute savings from 90 m^2 and beyond. The greater the number of consumers, the higher our tank sizes are optimised and plotted on larger roof areas.

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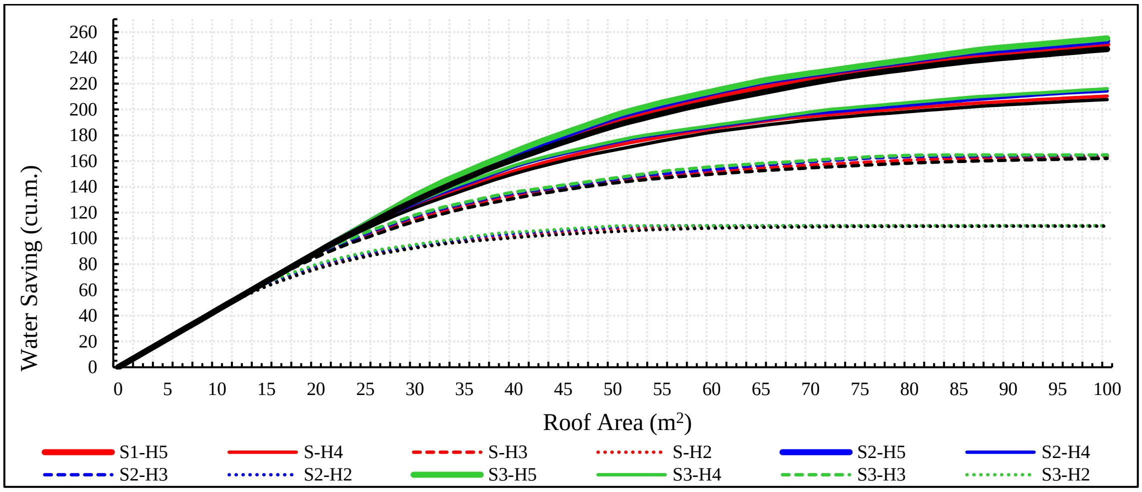

Fig. 5. Yearly water savings as a function of storage sizes, water demand, roof area, and rainfall characteristics at 36.9% probability of exceedance in Surigao del Sur, Caraga Region

Sources: Authors, 2023

Households may now decide how large their rainwater system is based on how they weigh the benefits and costs. Prices vary on the sizes of tanks or storage, depending on the availability of funds. One should remember that in most cases, one large tank will cost around 23.3% less than three (3) smaller tanks of equal size (Thomas & Martinson, 2007, p. 71).

Figure 6 to Figure 9 below illustrates the time duration for a tank to fill (in hours) of tank sizes S0.5, S1, S2, with respect to roof areas (run-off factor is 0.9) on the severity of rainfall. Consequently, storage of different sizes will have faster (less time needed) to get filled as roof areas increase (Allen & Haarhoff, 2015; Imteaz et al., 2011; Lopes et al., 2017; Ward et al., 2010). RWH tanks' efficiency for flood protection has been determined to depend on rainfall factors since RWH tanks have less influence on the surcharge from the drainage network as rainfall depth, intensity, and duration increase (Jamali et al., 2020). Nevertheless, time which is vital against flood risks (Rapant & Kolejka, 2021; Hapuarachchi et al., 2011; Konstantine P. Georgakakos, 2006; Creutin & Borga, 2003; K. P. Georgakakos, 1986) will be given to downtown settlers to react should the local government request, or uptown communities empty their storages before predicted heavy rain.

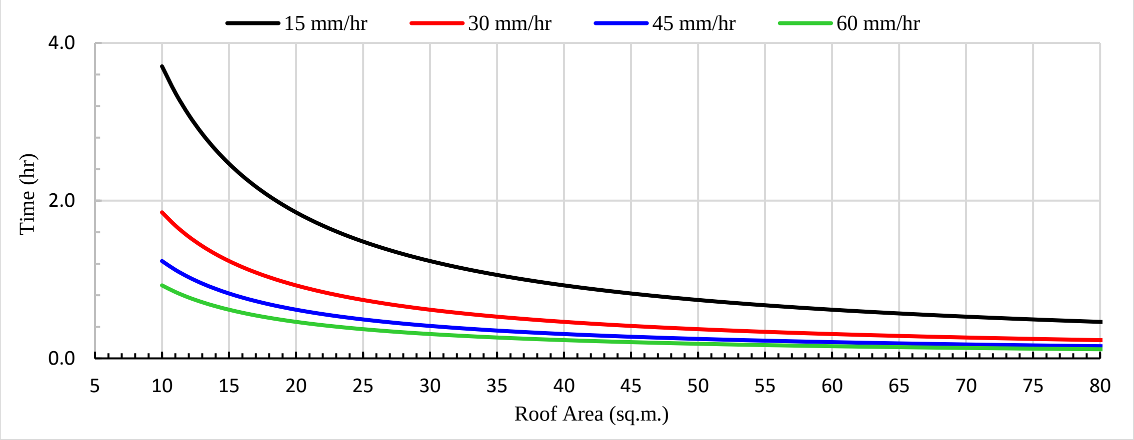

Fig. 6. Time duration to fill 0.5 cubic meter tank (S0.5) on different rainfall intensities (mm/hr)

Sources: Authors, 2023

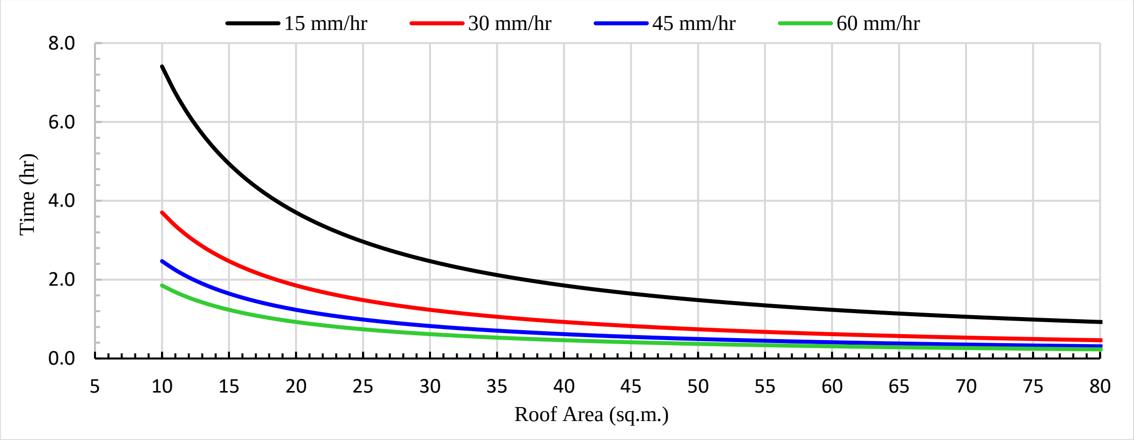

Fig. 7. Time duration to fill 1 cubic meter tank (S1) on different rainfall intensities (mm/hr)

Sources: Authors, 2023

https://doi.org/10.24191/ bej.v21i1.479

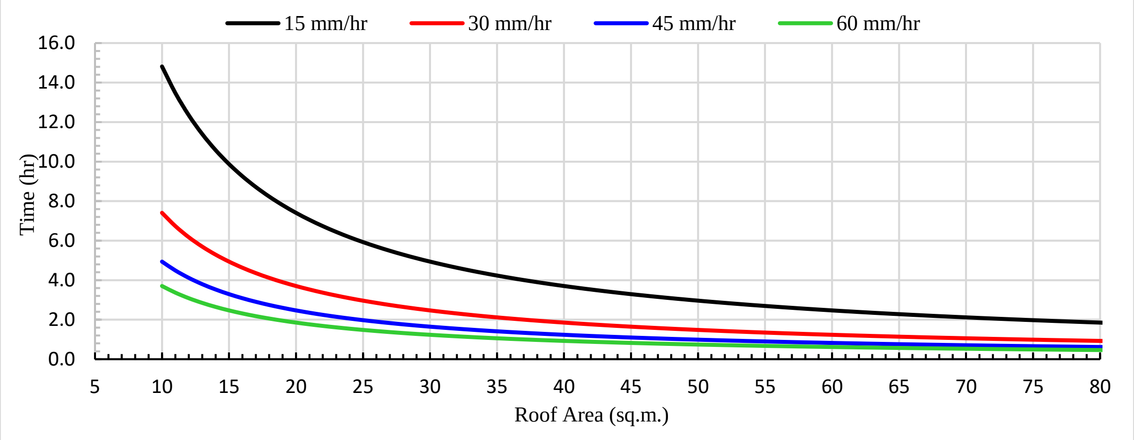

Fig. 8. Time duration to fill 1 cubic meter tank (S2) on different rainfall intensities (mm/hr)

Sources: Authors, 2023

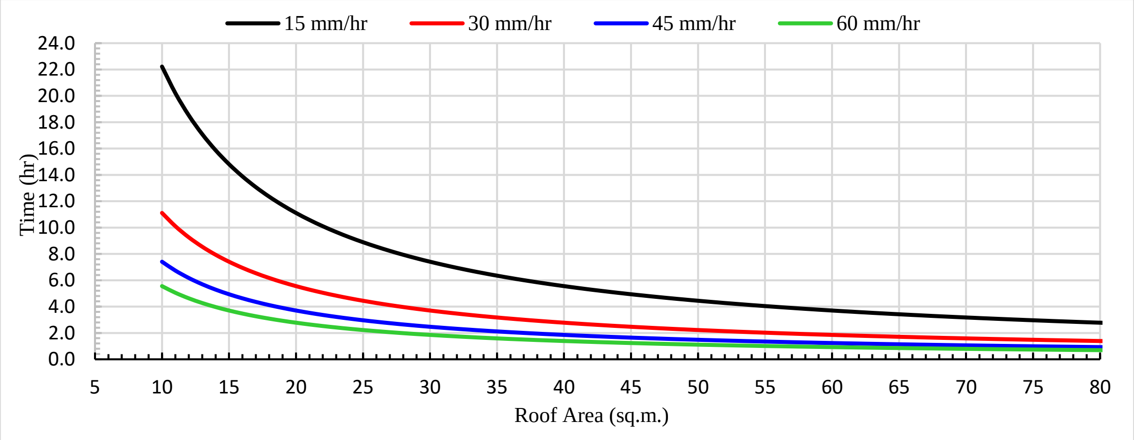

Fig. 9. Time duration to fill 1 cubic meter tank (S3) on different rainfall intensities (mm/hr)

Sources: Authors, 2023

Housing Project Types, and Rainwater Catchment and Optimum Storage Size

Table 2 illustrates the yearly water savings based on the output that generated Figure 5, given the housing types (HLURB, 2009; HLURB, 2008) in the Philippines, indicating the orange-highlighted values as the optimum rainwater tanks or storage sizes (curve starts to saturate) for each type (see Appendix A). Results suggest that socialised housing projects have an optimised one (1) cubic meter rainwater storage. In contrast, the economic housing, medium-cost housing, and open market housing units may be provided with two (2) cubic meter storage. As the requirement of affordable housing would limit the profit for housing developers, the least values were recommended to buffer their expenses (Saleh et al., 2022; Moghayedi et al., 2021; Uwayezu & Vries, 2020; Olanrewaju & Idrus, 2019)

Table 2. Yearly water savings based on housing project types optimised rainwater storage capacity

Housing Project Type	Minimum Floor Area (sq. m.)	Probable Roof Area (sq. m.) with one (1) meter roof overhang	Yearly Water Savings (in cubic meters) Given the Rainwater Storage Capacity for a Typical of Four (4) Family Members			Yearly Water Savings (in cubic meters) Given the Rainwater Storage Capacity for a Typical of Five (5) Family Members		
			1 Cu. M.	2 Cu. M.	3 Cu. M.	1 Cu. M.	2 Cu. M.	3 Cu. M.
Socialized	18	39	150	153	154	160	163	164
Economic	22	45	163	166	167	177	179	181
Medium Cost	30	56	180	182	183	202	205	207
Open Market	42	72	196	198	200	226	229	230

Sources: Authors, 2023

Flooding Resiliency Simulation

The types of knowledge utilised and the amount of ownership by the various entities participating in governance processes impact its successful application in urban management (Hordijk & Baud, 2006). Adaptive forms of governance in cooperation with the community are best suited to dealing with the uncertainty and complexity involved with social-ecological systems reacting to natural problems (Fournier et al., 2016; Lo et al., 2015; Eriksen & Selboe, 2012; Frank et al., 2011; Marfai et al., 2008). Flood-resilient communities are best served by governments that adopt proactive and aggressive actions, whether via laws, legislation, or incentives (Cao, 2023; Ibrahim, et. al., 2023; Warsilah & Choerunnisa, 2023; Chang et al., 2018; Driessen, et. al., 2016; Vale, 2014). Brankenridge et al. (2017) recommended that regions of near-yearly flooding be subjected to the strictest development or land-use rules to protect water conveyance and storage during significant floods.

Consider a hypothetical scenario wherein a group of residential housing projects will be constructed in an uptown part of a city in Surigao del Sur, Caraga Region, Philippines. Based on the information, the immediate local government unit (LGU) has already implemented an ordinance requiring rainwater catchment and storage for new establishments, particularly housing projects, for water-saving and flood risk reduction (Ilyasa et al., 2020; Lusiana & Widiyarta, 2021). Optimum sizes of storage were recommended from the result of this study. Suppose there are thousand (1000) of economic housing units with designed household dwellings for four (4) to be built. Based on Figure 1, the developer provided a two (2) cubic meter capacity rainwater reservoir, saving hundred and sixty-six (166) cubic meters yearly. When a service provider imposes a Php 20.00 per cubic meter of water for the entire year, there will be Php 2,320 savings for each dwelling. Furthermore, the project's expected yearly water stress reduction in the area will be 166,000 cubic meters.

Now, suppose an incoming heavy rain with forecasted rain intensity of 45 mm/hr is coming, and all these uptown residents heeded the request of the LGU to empty their storage a day prior. Therefore, the run-off reduction in downtown areas will be 2,000 cubic meters, giving a valuable reaction time of at least 1.097 hours or 65.82 minutes (refer to Appendix B and Figure 2) for the community to react to possible floods brought by that volume of water. Research suggests that the Expected Annual Damage (EAD) of flooding would decrease by up to 30% (Jamali et al., 2020) with a 28-35% floodwater decrease (Akter et al., 2020; Freni & Liuzzo, 2019) once Rain Water Harvesting (RWH) tanks were installed with accompanied water-saving advantages.

CONCLUSION

This research provided information about optimised rainwater catchment and storage systems appropriate for Surigao del Sur, Caraga Region, Philippines residents. Yearly water savings vary regarding the reservoir capacity, the number of consumers, and roof areas. There are suggested limitations of catchment areas

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concerning storage and vice versa because there is part of the curve whereby combined sizes of roof areas and storage as savings variables would cease to provide benefits. Integrated residential rainwater harvesting facilities in uptown areas could significantly reduce heavy rainfall and derivatively reduce floods among low-lying communities. Furthermore, it also provides sufficient time for preparation in downtown areas.

RECOMMENDATIONS

(i) The researchers only utilised eleven (11) years of data from PAG-ASA Hinatuan, Surigao del Sur, Caraga Region, Philippines. For higher accuracy, it is recommended to use thirty (30) years or more precipitation data;
(ii) It is recommended for the Local Government Unit within Surigao del Sur, Caraga Region, to craft and implement local ordinances about rainwater harvesting facilities of incoming residential housing projects for austerity measures, relieve water stress in the area, increase the community's resilience against flood risks, and provide sufficient time for downtown communities to react to flooding;
(iii) It is also recommended to residents in Surigao del Sur, Caraga Region to install rainwater harvesting and storage systems in their homes to: (a) ensure water supply in the aftermath of natural hazards (earthquakes, typhoons, tsunamis, landslides, liquefaction) or man-made disasters (like terrorism and insurgencies) that may disrupt water pipes or power supply resulting in the water supply cut-offs; (b) minimise the chance of water disruption for both scheduled and unscheduled repair and maintenance of water systems; (c) sustain women and children’s' hygiene and sanitation; (d) be part of the solutions to turbidity issues of water supplies during heavy rain occasions; and as a positive response to DILG Memorandum Circular No. 2012-02 entitled "Promoting the Construction of Rainwater Collectors in All Barangays in the Philippines to Mitigate the Adverse Impact of Climate Change"; and
(iv) Monitoring and evaluating the policy through research for enhancement is recommended regularly.

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CONFLICT OF INTEREST STATEMENT

The authors conducted this research without any self-benefits or commercial or financial conflicts and hereby declare the absence of conflicting interests with the North Eastern Mindanao State University as the funder.

AUTHORS’ CONTRIBUTIONS

Anastacio G. Pantaleon, Jr. and Franco G. Pantaleon conceptualised the central research idea, provided the research framework, conducted the research, and wrote and revised the article. They also anchored the review and revisions and approved the article submission. Jun Rey S. Lincuna provided vital insights, carried out data analysis and graphical presentations, and was assisted by Leo Ian D. Jovero.

REFERENCES

A Oraya, A. F. (2023). Rainwater harvesting tank sizing: a case in urban catchments in Metro Cebu. *Iop Conference Series Earth and Environmental Science*. https://doi.org/10.1088/1755-1315/1184/1/012014

Adikari, Y., Osti, R., & Noro, T. (2010). Flood-related disaster vulnerability: An impending crisis of megacities in Asia. *Journal of Flood Risk Management*, *3*(3), 185–191. https://doi.org/10.1111/j.1753-318X.2010.01068.x

Ahern, M., Kovats, R. S., Wilkinson, P., Few, R., & Matthies, F. (2005). Global health impacts of floods: epidemiologic evidence. *Epidemiologic Reviews, 27*(1), 36–46. https://doi.org/10.1093/EPIREV/MXI004

Ahmed, E. S. M. S., & Mays, L. W. (2013). Model for determining real-time optimal dam releases during flooding conditions. *Natural Hazards*, *65*(3), 1849–1861. https://doi.org/10.1007/s11069-012-0444-6

Akter, A., Tanim, A. H., & Islam, M. K. (2020). Possibilities of urban flood reduction through distributed-scale rainwater harvesting. *Water Science and Engineering*, *13*(2), 95–105. https://doi.org/10.1016/j.wse.2020.06.001

Alcantara, J. C., & Christopher, J. (2019). Overview of the societal impacts of floods in the Philippines. *Parliament Institute of Cambodia.* September Issue. https://pcasia.org/pic/wp-content/uploads/simple-file-list/20191014_Overview-of-the-Societal-Impacts-of-the-Philippines.pdf

Alfonso, C. D. Q., Sundo, M. B., Zafra, R. G., Velasco, P. P., Aguirre, J. J. C., & Madlangbayan, M. S. (2019). Flood risk assessment of major river basins in the Philippines. *International Journal of GEOMATE, 17*(64), 201–208. https://doi.org/10.21660/2019.64.17155

Andres, J. F., & Loretero, M. E. (2021). Energy equivalent of rainwater harvesting for high-rise building in the Philippines. *Civil Engineering and Architecture*, *9*(1), 74–84. https://doi.org/10.13189/cea.2021.090106

B. Racoma, B. A., Klingaman, N. P., Holloway, C. E., Schiemann, R., & Bagtasa, G. (2021). Tropical cyclone characteristics associated with extreme precipitation in the Northern Philippines. *International Journal of Climatology*. https://doi.org/10.1002/joc.7416

Balogun, I. I., Sojobi, A. O., & Oyedepo, B. O. (2016). Assessment of rainfall variability, rainwater harvesting potential and storage requirements in Odeda local government area of Ogun State in South-Western Nigeria. *Cogent Environmental Science, 2*(1), 1–24. https://doi.org/10.1080/23311843.2016.1138597

Bañados, J. H., & Quijano, I. P. (2022). Rainwater retention site assessment for urban flood risk reduction and flood defence in Mandaue City, Philippines. *Isprs Annals of the Photogrammetry Remote Sensing and Spatial Information Sciences*. https://doi.org/10.5194/isprs-annals-x-3-w1-2022-1-2022

Basack, S., Loganathan, M., Goswami, G., Baruah, P., & Alam, R. (2022). Review of risk assessment and mitigation measures of coastal aquifers vulnerable to saline water intrusion. *Polish Journal of Environmental Studies*. https://doi.org/10.15244/pjoes/142382

Bayoumy, S. H., El-Marsafy, S. M., & Ahmed, T. S. (2020). Optimization of a saturated gas plant: meticulous simulation-based optimization–a case study. *Journal of Advanced Research*, *22*, 21-33. https://doi.org/10.1016/j.jare.2019.11.011

Bernard, S. M., Samet, J. M., Grambsch, A., Ebi, K. L., & Romieu, I. (2001). The potential impacts of climate variability and change on air pollution-related health effects in the United States. *Environmental Health Perspectives, 109*(SUPPL. 2), 199–209. https://doi.org/10.2307/3435010

Berwanger, H., & Ghisi, E. (2018). Investment feasibility analysis of rainwater harvesting in a building in Brazil. *Water Science and Technology: Water Supply*, *18*(4), 1497–1504. https://doi.org/10.2166/ws.2017.218

Borgonia, K. M. M., & Fornis, R. L. (2020). Estimation of the reduction in flood peak and flood volume due to rooftop rainwater harvesting for nonpotable use. *AIP Conference Proceedings*, 2278, 1–8.

https://doi.org/10.1063/5.0014516

Bourque L.B., Siegel J.M., Kano M., & Wood M.M. (2007). Morbidity and mortality associated with disasters. In: handbook of disaster research. Handbooks of sociology and social research. *Springer, New York, NY*. https://doi.org/10.1007/978-0-387-32353-4_6

Brakenridge, G. R., Syvitski, J. P. M., Niebuhr, E., Overeem, I., Higgins, S. A., Kettner, A. J., & Prades, L. (2017). Design with nature: causation and avoidance of catastrophic flooding, Myanmar. *Earth-Science Reviews*, *165,* 81–109. https://doi.org/10.1016/j.earscirev.2016.12.009

Brandalise, M., Prandel, J., Quadros, F., Rovani, I., Malysz, M., & Decian, V. (2019). Influence of urbanization on the dynamics of the urban Vegetation Coverage Index (VCI) in Erechim (RS). *Floresta e Ambiente*, *26*(2). https://doi.org/10.1590/2179-8087.030117

Burns, M. J., Fletcher, T. D., Hatt, B. E., Anthony, R., & Walsh, C. J. (2010). Can allotment-scale rainwater harvesting manage urban flood risk and protect stream health? *7th International Conference on Sustainable Techniques and Strategies for Urban Water Management, 1–10*. https://hal.science/hal-03296680/document

Cabrera, J. S., & Lee, H. S. (2018). Impacts of climate change on flood-prone areas in Davao Oriental, Philippines. *Water*. https://doi.org/10.3390/w10070893

Campisano, A., & Modica, C. (2012). Regional scale analysis for the design of storage tanks for domestic rainwater harvesting systems. *Water Science and Technology*, *66*(1), 1–8. https://doi.org/10.2166/wst.2012.171

Cao, H. (2023). Urban resilience: concept, influencing factors and improvement. *Frontiers in Business, Economics and Management*, *9*(1), 343-346. https://doi.org/10.54097/fbem.v9i1.8777

Chandrappa, R., Gupta, S., & Kulshrestha, U. C. (2011). Hazard and risk assessment. *Coping with Climate Change, 201–212*. https://doi.org/10.1007/978-3-642-19674-4_13

Chang, N. Bin, Lu, J. W., Chui, T. F. M., & Hartshorn, N. (2018). Global policy analysis of low impact development for stormwater management in urban regions. *Land Use Policy, 70* (June 2016), 368–383. https://doi.org/10.1016/j.landusepol.2017.11.024

Chen, Y. Y., Chuang, Y. J., Huang, C. H., Lin, C. Y., & Chien, S. W. (2012). The adoption of fire safety management for upgrading the fire safety level of existing hotel buildings. *Building and Environment*, *51*, 311–319. https://doi.org/10.1016/j.buildenv.2011.12.001

Chen, Y., Zhou, H., Zhang, H., Du, G., & Zhou, J. (2015). Urban flood risk warning under rapid urbanization. *Environmental Research*, *139,* 3–10. https://doi.org/10.1016/j.envres.2015.02.028

Chiu, Y. R., Tsai, Y. L., & Chiang, Y. C. (2015). Designing rainwater harvesting systems cost-effectively in a urban water-energy saving scheme by using a GIS-simulation based design system. *Water (Switzerland), 7*(11), 6285–6300. https://doi.org/10.3390/w7116285

Cinco, T. A., de Guzman, R. G., D. Ortiz, A. M., Delfino, R. J., Lasco, R. D., Hilario, F. D., Juanillo, E. L., Barba, R., & Ares, E. D. (2016). Observed trends and impacts of tropical cyclones in the Philippines. *International Journal of Climatology*. https://doi.org/10.1002/joc.4659

Corporal-Lodangco, I. L., & Leslie, L. M. (2016). Climatology of Philippine tropical cyclone activity: 1945–2011. *International Journal of Climatology*. https://doi.org/10.1002/joc.4931

Costa, H., Floater, G., & Finnegan, J. (2016). Climate-resilient cities. *In The Economics of Climate-Resilient Development*. https://doi.org/10.4337/9781785360312.00018

CRED. (2019). Now is the time to not give up. Natural Disasters 2019. Brussels. https://cred.be/sites/default/files/adsr_2019.pdf

Creutin, J. D., & Borga, M. (2003). Radar hydrology modifies the monitoring of flash-flood hazard. *Hydrological Processes*, *17*(7), 1453–1456. https://doi.org/10.1002/hyp.5122

de Bruijn, K. M. (2004). Resilience and flood risk management. *Water Policy*, *6*(1), 53–66. https://doi.org/10.2166/wp.2004.0004

De Carvalho, R. M., & Szlafsztein, C. F. (2019). Urban vegetation loss and ecosystem services: The influence on climate regulation and noise and air pollution. *Environmental Pollution*, *245*, 844–852. https://doi.org/10.1016/j.envpol.2018.10.114

Department of Public Works and Highways. (2019). Annual report 2018. *In AIMS Mathematics*. https://doi.org/10.3934/Math.2019.1.166

Dirk, R. (2013). Frequency analysis of rainfall data. *In: College on Soil Physics— 30th Anniversary (1983-2013), The Abdus Salam International Centre for Theoretical Physica*, 244-10. http://indico.ictp.it/event/a12165/session/21/contribution/16/material/0/0.pdf

DOST-PAG-ASA. (n.d.). Climate of the Philippines. https://www.pagasa.dost.gov.ph/information/climate-philippines

Driessen, P. P., Hegger, D. L., Bakker, M. H., van Rijswick, H. F., & Kundzewicz, Z. W. (2016). Toward more resilient flood risk governance. *Ecology and Society*, *21*(4). https://www.jstor.org/stable/26269990

Eriksen, S., & Selboe, E. (2012). The social organization of adaptation to climate variability and global change: the case of a mountain farming community in Norway. *Applied Geography*, *33*(1), 159–167. https://doi.org/10.1016/j.apgeog.2011.10.003

Esguerra, A. T., Madrid, A. E., & Nillo, R. G. (2011). Rainwater harvesting , quality assessment and utilization in Region I. *E-International Scientific Research Journal*, *3*(2), 145–155. http://www.eisrjc.com/documents/Rainwater_Harvesting_1325914607.pdf

ESRI. (2013). Philippines average household size. https://www.arcgis.com/home/item.html?id=5e9a37f7a6734cac9e5c3ec0431e56f3

European Civil Protection and Humanitarian Aid Operations. (2021). ECHO flash. *European Union*. http://erccportal.jrc.ec.europa.eu/ECHO-Flash

Farreny, R., Gabarrell, X., & Rieradevall, J. (2011). Cost-efficiency of rainwater harvesting strategies in dense Mediterranean neighbourhoods. Resources, *Conservation and Recycling*, 55(7), 686–694. https://doi.org/10.1016/j.resconrec.2011.01.008

Fewkes, A., & Warm, P. (2000). Method of modelling the performance of rainwater collection systems in the United Kingdom. *Building Services Engineering Research and Technology, 21*(4), 257–265. https://doi.org/10.1177/014362440002100408

Fournier, M., Larrue, C., Alexander, M., Hegger, D., Bakker, M., Pettersson, M., Crabbé, A., Mees, H., & Chorynski, A. (2016). Flood risk mitigation in Europe: how far away are we from the aspired forms of adaptive governance? *Ecology and Society*, Published Online: Dec 19, 2016 | Doi:10.5751/ES-08991-210449, 21(4). https://doi.org/10.5751/ES-08991-210449

Frank, E., Eakin, H., & López-Carr, D. (2011). Social identity, perception and motivation in adaptation to climate risk in the coffee sector of Chiapas, Mexico. *Global Environmental Change*, *21*(1), 66–76. https://doi.org/10.1016/j.gloenvcha.2010.11.001

Franta, B., Roa-Quiaoit, H. A., Lo, D., & Narisma, G. (2016). Climate disasters in the Philippines: a case study of immediate causes and root drivers from Cagayan de Oro, Mindanao and Tropical Storm Sendong/Washi. *Environment & Natural Resources Program Belfer Center for Science and International Affairs Harvard Kennedy School*, 1–30. https://www.belfercenter.org/sites/default/files/files/publication/Philippines Climate Disasters - final.pdf

Freni, G., & Liuzzo, L. (2019). Effectiveness of rainwater harvesting systems for flood reduction in residential urban areas. Water (Switzerland), 11(7). https://doi.org/10.3390/w11071389

Fresnido, A. M. B., & Esposo-betan, S. M. S. (2018). Going green: sustainable practices in Philippine libraries. *IFLA World Library and Information Congress*, 1–9. http://library.ifla.org/2173/1/187-fresnido-en.pdf

Froude, M., & Petley, D. (2018). Global fatal landslide occurrence from 2004 to 2016. *Natural Hazards and Earth System Science*. https://doi.org/10.5194/nhess-18-2161-2018

Furumai, H. (2016). Evaluation of rainwater harvesting and use potential considering climate change in Arakawa watershed. *Novatech,* 1–4. http://documents.irevues.inist.fr/bitstream/handle/2042/60473/3B72-233FUR.pdf

Georgakakos, Konstantine P. (1986). On the design of national, real-time warning systems with capability for site-specific, flash- flood forecasts. *Bulletin - American Meteorological Society*, *67*(10), 1233–1239. https://doi.org/10.1175/1520-0477(1986)067

Georgakakos, Konstantine P. (2006). Analytical results for operational flash flood guidance. *Journal of Hydrology*, *317*(1–2), 81–103. https://doi.org/10.1016/J.JHYDROL.2005.05.009

Gerolin, A., Kellagher, R. B., & Faram, M. G. (2010). Rainwater harvesting systems for stormwater management : Feasibility and sizing considerations for the UK Utilisation des récupérateurs d ’ eaux de pluie pour le contrôle du ruissellement à la source : faisabilité et méthode de dimensionnement au Royaume-. *Novatech,* June, 1–10. http://documents.irevues.inist.fr/bitstream/handle/2042/35790/21502-100GER.pdf

Ghisi, E. (2010). Parameters influencing the sizing of rainwater tanks for use in houses. *Water Resources Management*, *24*(10), 2381–2403. https://doi.org/10.1007/s11269-009-9557-4

Gill, S. E., Handley, J. F., Ennos, A. R., & Pauleit, S. (2007). Adapting cities for climate change: the role of the green infrastructure LK . *Built Environment. TA - TT -*, *33*(1), 115–132. https://slc.on.worldcat.org/oclc/123729317

Golz, S., Naumann, T., Neubert, M., & Günther, B. (2016). Heavy rainfall: An underestimated environmental risk for buildings? *E3S Web of Conferences*, 7. https://doi.org/10.1051/e3sconf/20160708001

Guan, X., Shen, H., Li, X., Gan, W., & Zhang, L. (2019). A long-term and comprehensive assessment of the urbanization-induced impacts on vegetation net primary productivity. *Science of the Total Environment*, *669*, 342–352. https://doi.org/10.1016/j.scitotenv.2019.02.361

Hapuarachchi, H. A. P., Wang, Q. J., & Pagano, T. C. (2011). A review of advances in flash flood forecasting. *Hydrological Processes*, *25*(18), 2771–2784. https://doi.org/10.1002/hyp.8040

Helmreich, B., & Horn, H. (2009). Opportunities in rainwater harvesting. *Desalination, 248*(1–3), 118–124. https://doi.org/10.1016/j.desal.2008.05.046

HLURB. (2008). B.P. no. 220, *Revised IRR*. https://dhsud.gov.ph/wp-content/uploads/Laws_Issuances/02_IRR/Revised_IRR_BP220_2008.pdf

HLURB. (2009). P.D. no. 957, *Revised IRR.* https://dhsud.gov.ph/wp-content/uploads/Laws_Issuances/02_IRR/IRRPD957.pdf

Hordijk, M., & Baud, I. (2006). The role of research and knowledge generation in collective action and urban governance: How can researchers act as catalysts? *Habitat International, 30*(3), 668–689. https://doi.org/10.1016/j.habitatint.2005.04.002

Huang, W.-C., & Hsieh, C.-L. (2010). Real-time reservoir flood operation during typhoon attacks. *Water Resources Research*, *46*(7), 7528. https://doi.org/10.1029/2009WR008422

Ibrahim, A., Salifu, A. H., & Peprah, C. (2023). Does governance matter when disaster looms? zooming into proactive institutional measures for flood risk management. *International Journal of Disaster Risk Reduction, 97*, 104021. https://doi.org/10.1016/j.ijdrr.2023.104021

Ilyasa, F., Rahmayanti, H., Muzani, M., Ichsan, I. Z., & Suhono, S. (2020). Environmental education for prevent disaster: a survey of students knowledge in beginning new normal of COVID-19. *International Journal on Advanced Science Education and Religion*. https://doi.org/10.33648/ijoaser.v3i2.60

Imteaz, M. A., Adeboye, O. B., Rayburg, S., & Shanableh, A. (2012). Rainwater harvesting potential for southwest Nigeria using daily water balance model. *Resources, Conservation and Recycling, 62,* 51–55. https://doi.org/10.1016/j.resconrec.2012.02.007

Imteaz, M. A., Ahsan, A., Naser, J., & Rahman, A. (2011). Reliability analysis of rainwater tanks in Melbourne using daily water balance model. *Resources*, *Conservation and Recycling*, *56*(1), 80–86. https://doi.org/10.1016/j.resconrec.2011.09.008

Ishak, H. N., & Hashim, M. A. (2018). Dam pre-release as an important operation strategy in reducing flood impact in Malaysia. *E3S Web of Conferences*, *34*, 1–6. https://doi.org/10.1051/e3sconf/20183402017

Islam, M. M., N-F Chou, F., Kabir, M. R., & N-F Chou, Á. F. (2011). Feasibility and acceptability study of rainwater use to the acute water shortage areas in Dhaka City, Bangladesh. *Natural Hazards (Springer) 56*, 93–111. https://doi.org/10.1007/s11069-010-9551-4

Jamali, B., Bach, P. M., & Deletic, A. (2020). Rainwater harvesting for urban flood management – an integrated modelling framework. *Water Research*, *171*, 115372. https://doi.org/10.1016/j.watres.2019.115372

Jameson, S., & Baud, I. (2016). Varieties of knowledge for assembling an urban flood management governance configuration in Chennai, India. *Habitat International*, 54, 112–123. https://doi.org/10.1016/j.habitatint.2015.12.015

Jha, S., Martinez, A., Quising, P., Ardaniel, Z., & Wang, L. (2018). ADBI working paper series natural disasters, public spending, and creative destruction: a case study of the Philippines. *Asian Development Bank Institute.* 817. https://www.adb.org/publications/natural-disasters-public-spending-and-creative-destruction-

Johnson, L. R., Trammell, T. L., Bishop, T. J., Barth, J., Drzyzga, S., & Jantz, C. (2020). Squeezed from all sides: urbanization, invasive species, and climate change threaten riparian forest buffers. *Sustainability, 12*(4), 1448. https://doi.org/10.3390/su12041448

Jonkman, S. N., & Kelman, I. (2005). An analysis of the causes and circumstances of flood disaster deaths. *Disasters*, *29*(1), 75–97. https://doi.org/10.1111/j.0361-3666.2005.00275.x

Khaerani, T. R. (2022). The role of local government in disaster management (study on the regional disaster management agency in flood disaster mitigation in Samarinda city). *Cosmogov.* https://doi.org/10.24198/cosmogov.v8i1.33118

Khastagir, A., & Jayasuriya, N. (2010). Optimal sizing of rain water tanks for domestic water conservation. *Journal of Hydrology, 381*(3–4), 181–188. https://doi.org/10.1016/j.jhydrol.2009.11.040

Kim, K., & Yoo, C. (2009). Hydrological Modeling and Evaluation of Rainwater Harvesting Facilities: Case Study on Several Rainwater Harvesting Facilities in Korea. *Journal of Hydrologic Engineering, 14*(6), 545–561. https://doi.org/10.1061/(asce)he.1943-5584.0000030

Kinkade-Levario, H. (2007). Design for water: rainwater harvesting, stormwater catchment, and alternate water reuse. In *New Society Publishers* (Vol. 1, Issue 1). https://doi.org/10.1080/14486563.2014.960058

Kubanek, J. (2017). Optimal decision making and matching are tied through diminishing returns. *Proceedings of the National Academy of Sciences, 114*(32), 8499-8504. https://doi.org/10.1073/pnas.1703440114

Langousis, A., & Veneziano, D. (2007). Intensity-duration-frequency curves from scaling representations of rainfall. *Water Resources. Res, 43*, 2422. https://doi.org/10.1029/2006WR005245

Li, G. F., Xiang, X. Y., Tong, Y. Y., & Wang, H. M. (2013). Impact assessment of urbanization on flood risk in the Yangtze River Delta. *Stochastic Environmental Research and Risk Assessment, 27*(7), 1683–1693. https://doi.org/10.1007/s00477-013-0706-1

Liao, K. H. (2012). A theory on urban resilience to floods-A basis for alternative planning practices. *Ecology and Society, 17*(4). https://doi.org/10.5751/ES-05231-170448

Liu, J., Byrne, D., & Devendorf, L. (2018). Design for collaborative survival: an inquiry into human-fungi relationships. *Conference on Human Factors in Computing Systems - Proceedings, 2018-April*, 1–13. https://doi.org/10.1145/3173574.3173614

Lo, A. Y., Xu, B., Chan, F. K. S., & Su, R. (2015). Social capital and community preparation for urban flooding in China. *Applied Geography, 64*, 1–11. https://doi.org/10.1016/j.apgeog.2015.08.003

Lopes, V. A. R., Marques, G. F., Dornelles, F., & Medellin-Azuara, J. (2017). Performance of rainwater harvesting systems under scenarios of non-potable water demand and roof area typologies using a stochastic approach. *Journal of Cleaner Production, 148*, 304–313. https://doi.org/10.1016/j.jclepro.2017.01.132

Lu, Z., Sun, L., & Zhou, Y. (2021). A method for rainfall detection and rainfall intensity level retrieval from x-band marine radar images. *Applied Sciences* (*Switzerland*), 11(4), 1–22. https://doi.org/10.3390/app11041565

Lusiana, N. A., & Widiyarta, A. (2021). Disaster mitigation as an effort to minimize the impact of floods in Lamongan District. *Dia Jurnal Ilmiah Administrasi Publik*. https://doi.org/10.30996/dia.v19i1.5160

Madden, I., Mariwala, A., Lindhart, M., Narayan, S., Arkema, K. K., Beck, M. W., Baker, J. W., & Suckale, J. (2023). Quantifying the fragility of coral reefs to hurricane impacts: a case study of the Florida Keys and Puerto Rico. *Environmental Research Letters*. https://doi.org/10.1088/1748-9326/acb451

Mahmoud, S. H., & Gan, T. Y. (2018). Urbanization and climate change implications in flood risk management: developing an efficient decision support system for flood susceptibility mapping. *Science of the Total Environment, 636*, 152–167. https://doi.org/10.1016/j.scitotenv.2018.04.282

Mahmoudi, A., & Feylizadeh, M. R. (2018). A grey mathematical model for crashing of projects by considering time, cost, quality, risk and law of diminishing returns. *Grey Systems: Theory and Application, 8*(3), 272-294. https:/doi/10.1108/GS-12-2017-0042

Marfai, M. A., King, L., Sartohadi, J., Sudrajat, S., Budiani, S. R., & Yulianto, F. (2008). The impact of tidal flooding on a coastal community in Semarang, Indonesia. *Environmentalist*, *28*(3), 237–248. https://doi.org/10.1007/s10669-007-9134-4

Matos, C., Bentes, I., Santos, C., Imteaz, M., & Pereira, S. (2015). Economic analysis of a rainwater harvesting system in a commercial building. *Water Resources Management*, 29(11), 3971–3986. https://doi.org/10.1007/s11269-015-1040-9

Matos, C., Santos, C., Pereira, S., Bentes, I., & Imteaz, M. (2013). Rainwater storage tank sizing: case study of a commercial building. *International Journal of Sustainable Built Environment*, *2*(2), 109–118. https://doi.org/10.1016/j.ijsbe.2014.04.004

McCoy, D., Montgomery, H., Arulkumaran, S., & Godlee, F. (2014). Climate change and human survival. *BMJ (Online)*, *348*(March), 1–2. https://doi.org/10.1136/bmj.g2351

Medina, M. A. P., & Catalon, B. G. (2015). Reducing our ecological footprint: developing sustainability scenarios for the College of Forestry and Environmental Science, Central Mindanao University. *Researchgate.Net*, *4*(July), 1–6. https://www.researchgate.net/profile/Michael_Arieh_Medina/publication/282231832_Reducing_our_Ecological_Footprint_Developing_Sustainability_Scenarios_for_the_College_of_Forestry_and_Environmental_Science_Central_Mindanao_University_Philippines/links/564d8

Melville-Shreeve, P., Ward, S., & Butler, D. (2016). Rainwater harvesting typologies for UK houses: a multi criteria analysis of system configuration. *In Water Resources Research Institute of The University of North Carolina (Issue 425)*. https://doi.org/https://doi.org/10.3390/w8040129

Mentens, J., Raes, D., & Hermy, M. (2006). Green roofs as a tool for solving the rainwater run-off problem in the urbanized 21st century? *Landscape and Urban Planning*, *77*(3), 217–226. https://doi.org/10.1016/j.landurbplan.2005.02.010

Moghayedi, A., Awuzie, B., Omotayo, T., Jeune, K., Massyn, M., Ekpo, C., … & Byron, P. (2021). A critical success factor framework for implementing sustainable innovative and affordable housing: a systematic review and bibliometric analysis. *Buildings*, *11*(8), 317. https://doi.org/10.3390/buildings11080317

Moruzzi, R. B., Garcia, M. L., & Oliveira, S. C. de. (2012). A proposal for reservoir volume calculation in rainwater harvesting systems. *Journal of Civil Engineering and Architecture*, *6*(6), 707–714. https://doi.org/10.17265/1934-7359/2012.06.008

National Disaster Risk Reduction and Management Council (NDRRMC). (2015). Philippines national progress report on the implementation of the Hyogo framework for action (2013-2015) organization: National Disaster Risk Reduction & Management Council Title/Position: OCD-NDRRMC. April. http://www.preventionweb.net/english/hyogo/progress/reports/

Newman, P. (2006). The environmental impact of cities. *Environment and Urbanization*, *18*(2), 275–295. https://doi.org/10.1177/0956247806069599

Nguyen, D. C., & Han, M. Y. (2017). Proposal of simple and reasonable method for design of rainwater harvesting system from limited rainfall data. *Resources, Conservation and Recycling*, *126*(July), 219–227. https://doi.org/10.1016/j.resconrec.2017.07.033

Nguyen, V. M., Ichikawa, Y., & Ishidaira, H. (2018). Exploring optimal tank size for rainwater harvesting systems in asian tropical climates. *Hydrological Research Letters*, 12(1), 1–6. https://doi.org/10.3178/hrl.12.1

Noor, N. M., & Abdul Maulud, K. N. (2022). Coastal vulnerability: A brief review on integrated assessment in southeast Asia. *Journal of Marine Science and Engineering*, 10(5), 595. https://doi.org/10.3390/jmse10050595

Nurjanah, A., & Apriliani, R. (2021). The role of community in disaster mitigation: the case of Umbulharjo Merapi monitoring community on Merapi Mount, Indonesia. *Jurnal Hubungan Internasional*. https://doi.org/10.18196/jhi.v10i1.12460

Okaka, F. O., & Odhiambo, B. (2018). Relationship between flooding and outbreak of infectious diseasesin Kenya: A review of the literature. *Journal of environmental and public health*, 2018. https://doi.org/10.1155/2018/5452938

Olanrewaju, A., & Idrus, A. (2019). What is determining affordable housing shortages in the greater kuala lumpur, malaysia?. *Property Management, 38*(1), 52-81. https://doi.org/10.1108/pm-05-2019-0025

Pachpute, J. S., Tumbo, S. D., Sally, H., Mul, M. L., & Tumbo, S. D. (2009). Sustainability of rainwater harvesting systems in rural catchment of Sub-Saharan Africa. *Water Resources Management*, *23,* 2815–2839. https://doi.org/10.1007/s11269-009-9411-8

Pandey, B., & Seto, K. C. (2015). Urbanization and agricultural land loss in India: comparing satellite estimates with census data. *Journal of Environmental Management*, *148,* 53–66. https://doi.org/10.1016/j.jenvman.2014.05.014

Pelak, N., & Porporato, A. (2016). Sizing a rainwater harvesting cistern by minimizing costs. *Journal of Hydrology*, 541, 1340–1347. https://doi.org/10.1016/j.jhydrol.2016.08.036

Philippine Atmospheric, Geophysical and Astronomical Services Administration. (n. d.) Weather terminologies. *Republic of the Philippines*. Accessed from http://bagong.pagasa.dost.gov.ph/information/weather-terminologies on August 30, 2021.

Pramudita, A. J. N., & Nugroho, J. (2021). *Post-Pandemic Community Resilience: Community and Economic Conditions of Wedi Village*. https://doi.org/10.2991/aebmr.k.210628.049

Qin, Y. (2020). Urban flooding mitigation techniques: a systematic review and future studies. *Water (Switzerland)*, 12(12). https://doi.org/10.3390/w12123579

Rapant, P., & Kolejka, J. (2021). Dynamic pluvial flash flooding hazard forecast using weather radar data. *Remote Sensing*, *13*, 2943. https://doi.org/https://doi.org/10.3390/rs13152943

Rappaport, E. N. (2000). Loss of life in the United States associated with recent Atlantic tropical cyclones. *Bulletin of the American Meteorological Society*, *81*(9), 2065–2073. https://doi.org/10.1175/1520-0477(2000)081

Roebuck, R. M., Oltean-Dumbrava, C., & Tait, S. (2011). Whole life cost performance of domestic rainwater harvesting systems in the United Kingdom. *Water and Environment Journal, 25*(3), 355–365. https://doi.org/10.1111/j.1747-6593.2010.00230.x

Saleh, A., Majid, R., Rahim, N., & Omar, M. (2022). Housing supply model for affordable homes in malaysia. *Environment-Behaviour Proceedings Journal, 7*(22), 127-133. https://doi.org/10.21834/ebpj.v7i22.4159

Sayers, P., Galloway, G., Penning-rowsell, E., Shen, F., Kang, W., Yiwei, C., & Le Quesne, T. (2013). Flood risk management a strategic approach: part of a series on strategic water management. In *Water and Sewerage Journal*. https://bit.ly/2TkeZHz

Schumacher, R. S. (2017). Heavy rainfall and flash flooding. *In Oxford Research Encyclopedia of Natural Hazard Science*. Oxford University Press. https://doi.org/10.1093/acrefore/9780199389407.013.132

Semaan, M., Day, S. D., Garvin, M., Ramakrishnan, N., & Pearce, A. (2020). Optimal sizing of rainwater harvesting systems for domestic water usages: A systematic literature review. *Conservation & Recycling: X,Volume 6*, 2020 https://doi.org/10.1016/j.rcrx.2020.100033

Shi, C., Liao, L., Li, H., & Su, Z. (2022). Which urban communities are susceptible to COVID-19? an empirical study through the lens of community resilience. *BMC Public Health*. https://doi.org/10.1186/s12889-021-12419-8

Starominski-Uehara, M. (2020). How structural mitigation shapes risk perception and affects decision-making. *Disasters*. https://doi.org/10.1111/disa.12412

Sulaiman, N., She, T. W., & Fernando, T. (2019). Community resilience frameworks for building disaster resilient community in Malaysia. *Planning Malaysia*. https://doi.org/10.21837/pmjournal.v17.i9.589

Swiss NGO DRR. (2014). *Disaster risk reduction and management in the Philippines*. *July*, 1–32. *CARITAS*. https://www.shareweb.ch/site/DRR/Documents/About%20Us/Risk_Assessment_Philippines_2014.pdf

Tan, G. H. (2023). Analysis of strategies for mitigation and adaptation to the impacts of climate change in the agricultural sector in Northern Philippines. *Ryerson University: Theses and dissertations.* https://doi.org/10.32920/ryerson.14644512

Teston, A., Geraldi, M. S., Colasio, B. M., & Ghisi, E. (2018). Rainwater harvesting in buildings in Brazil: A literature review. In Water (Switzerland) (Vol. 10, Issue 4). https://doi.org/10.3390/w10040471

Thomalla, F., Boyland, M., & Calgaro, E. (2017). Disasters and development in Southeast Asia toward equitable resilience and sustainability. In Routledge Handbook of Southeast Asian Development (pp. 342-361). *Routledge*. http://doi.org/10.4324/9781315726106-30

Thomas, T. H., & Martinson, D. B. (2007). Roofwater harvesting: a handbook for practitioners. *IRC International Water and Sanitation Centre.*

Torti, J. (2012). Floods in Southeast Asia: a health priority. *Journal of global health*, 2(2). http://doi.org/10.7189/jogh.02.020304

Tubog, M. V., Villahermosa, R. L., & Perong, J. G. (2023). Landslide susceptibility modeling derived from remote sensing, multi-criteria decision analysis, and GIS techniques: a case study in the Southeast Bohol Province, Philippines. *Research Square*. https://doi.org/10.21203/rs.3.rs-2547208/v1

Unite, B. (2021, July 14). DPWH's efforts in CARAGA lead to construction, fixing of over 1,300 km of roads – Manila Bulletin. *Manila Bulletin*. https://mb.com.ph/2021/07/14/dpwhs-efforts-in-caraga-leads-to-construction-fixing-of-over-1300-km-of-roads/

United Nations. (2021). Water-related hazards dominate list of 10 most destructive disasters. *UN News - Global Perspective Human Stories*. https://news.un.org/en/story/2021/07/1096302

Uwayezu, E., & Vries, W. (2020). Access to affordable houses for the low-income urban dwellers in kigali: analysis based on sale prices. *Land*, *9*(3), 85. https://doi.org/10.3390/land9030085

Vaes, G., & Berlamont, J. (2001). The effect of rainwater storage tanks on design storms. *Urban Water, 3*(4), 303–307. https://doi.org/10.1016/S1462-0758(01)00044-9

Vale, L. J. (2014). The politics of resilient cities: whose resilience and whose city? *Building Research & Information*, *42*(2), 191-201. https://doi.org/10.1080/09613218.2014.850602

Valeriano, O. C. S., Koike, T., Yang, K., Graf, T., Li, X., Wang, L., & Han, X. (2010). Decision support for dam release during floods using a distributed biosphere hydrological model driven by quantitative precipitation forecasts. *Water Resources Research*, *46*(10), 10544. https://doi.org/10.1029/2010WR009502

https://doi.org/10.24191/ bej.v21i1.479

Vårheim, A., Skare, R., Lenstra, N., Latham, K. F., & Grenersen, G. (2018). A research program for studying LAMs and community in the digital age. *Proceedings From the Document Academy*. https://doi.org/10.35492/docam/5/2/12

Viseu, T., & Almeida, A. B. de. (2009). Ecopath with ecosim: linking fisheries and ecology 1 why ecosystem modeling in fisheries? *WIT Transactions on State of the Art in Science and Engineering*, *36*, 1755–8336. https://doi.org/10.2495/978-1-84564- 2- / 14 9 06

Vojinovic, Z., Alves, A., Gómez, J. P., Weesakul, S., Keerakamolchai, W., Meesuk, V., & Sanchez, A. (2021). Effectiveness of small- and large-scale nature-based solutions for flood mitigation: the case of Ayutthaya, Thailand. *Science of the Total Environment*, *789*. https://doi.org/10.1016/j.scitotenv.2021.147725

Wang, Q., Wang, W., He, X., Zhou, W., Zhai, C., Wang, P., Tang, Z., Wei, C., Zhang, B., Xiao, L., & Wang, H. (2019). Urbanization-induced glomalin changes and their associations with land-use configuration, forest characteristics, and soil properties in Changchun, Northeast China. *Journal of Soils and Sediments*, *19*(5), 2433–2444. https://doi.org/10.1007/s11368-019-02266-x

Warsilah, H., & Choerunnisa, S. N. (2023). Climate change and flood: vulnerability and community resilience. In *Climate Change, Community Response and Resilience* (pp. 345-360). Elsevier. https://doi.org/10.1016/B978-0-443-18707-0.00018-7

World Bank. (2019). *Learning from Japan's experience in integrated urban flood risk management: a series of knowledge notes knowledge note 1: assessing and communicating urban flood risk*. https://policycommons.net/artifacts/1263270/learning-from-japans-experience-in-integrated-urban-flood-risk-management/1837543/

World Meteorological Organization. (2021). Water-related hazards dominate disasters in the past 50 years. https://public.wmo.int/en/media/press-release/water-related-hazards-dominate-disasters-past-50-years

Xu, W. D., Fletcher, T. D., Burns, M. J., & Cherqui, F. (2020). Real time control of rainwater harvesting systems: the benefits of increasing rainfall forecast window. *Water Resources Research*, *56*(9), 1–16. https://doi.org/10.1029/2020WR027856

Yonson, R. (2018). Floods and pestilence: diseases in Philippine urban areas. *EconDisCliCha* 2, 107–135. https://doi.org/10.1007/s41885-017-0021-2

Yonson, R. (2019). Disaster risk management policies and the measurement of resilience for Philippine regions. *Risk Analysis*. https://doi.org/10.1111/risa.13394

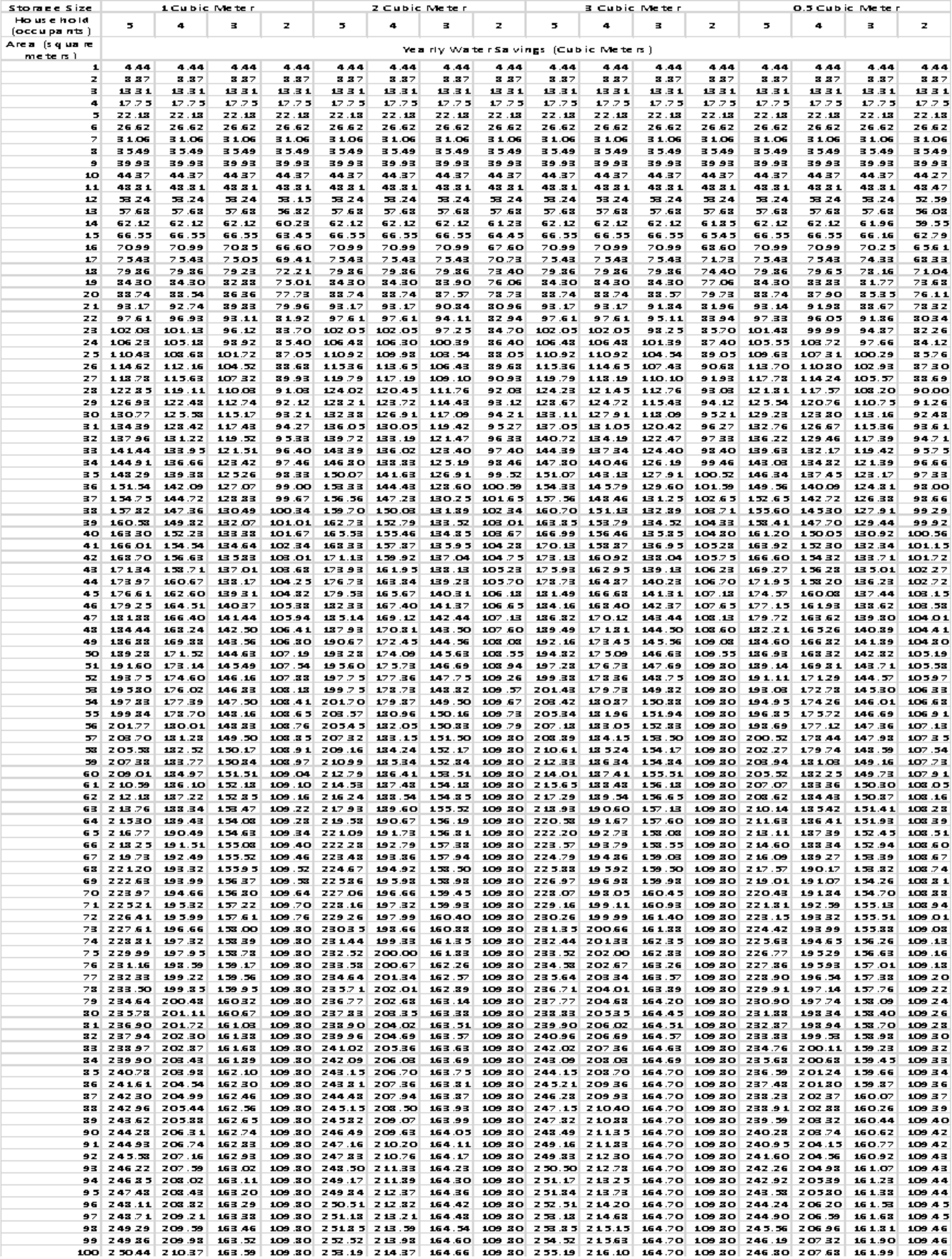
Zamboni, L. M. (2017). Theory and metrics of community resilience: a systematic literature review based on public health guidelines. *Disaster Medicine and Public Health Preparedness*. https://doi.org/10.1017/dmp.2017.22

Zevenbergen, C., Gersonius, B., & Radhakrishan, M. (2020). Flood resilience. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 378*(2168). https://doi.org/10.1098/rsta.2019.0212

Zhang, H., Ma, W., & Wang, X. (2008). Rapid urbanization and implications for flood risk management in hinterland of the Pearl River Delta, China: The Foshan Study. *Sensor*, *8*, 2223–2239. https://doi.org/doi:10.3390/s8042223

Zhang, X., & Hu, M. (2014). Effectiveness of rainwater harvesting in run-off volume reduction in a planned industrial park, China. *Water Resources Management, 28*(3), 671–682. https://doi.org/10.1007/s11269-013-0507-9

Appendix A



Storage Size	1 Cubic Meter				2 Cubic Meter				3 Cubic Meter				0.5 Cubic Meter			
Household (occupants)	5	4	3	2	5	4	3	2	5	4	3	2	5	4	3	2
Area (square meters)	Yearly Water Savings (Cubic Meters)															
1	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44
2	8.87	8.87	8.87	8.87	8.87	8.87	8.87	8.87	8.87	8.87	8.87	8.87	8.87	8.87	8.87	8.87
3	13.31	13.31	13.31	13.31	13.31	13.31	13.31	13.31	13.31	13.31	13.31	13.31	13.31	13.31	13.31	13.31
4	17.75	17.75	17.75	17.75	17.75	17.75	17.75	17.75	17.75	17.75	17.75	17.75	17.75	17.75	17.75	17.75
5	22.18	22.18	22.18	22.18	22.18	22.18	22.18	22.18	22.18	22.18	22.18	22.18	22.18	22.18	22.18	22.18
6	26.62	26.62	26.62	26.62	26.62	26.62	26.62	26.62	26.62	26.62	26.62	26.62	26.62	26.62	26.62	26.62
7	31.06	31.06	31.06	31.06	31.06	31.06	31.06	31.06	31.06	31.06	31.06	31.06	31.06	31.06	31.06	31.06
8	35.49	35.49	35.49	35.49	35.49	35.49	35.49	35.49	35.49	35.49	35.49	35.49	35.49	35.49	35.49	35.49
9	39.93	39.93	39.93	39.93	39.93	39.93	39.93	39.93	39.93	39.93	39.93	39.93	39.93	39.93	39.93	39.93
10	44.37	44.37	44.37	44.37	44.37	44.37	44.37	44.37	44.37	44.37	44.37	44.37	44.37	44.37	44.37	44.27
11	48.81	48.81	48.81	48.81	48.81	48.81	48.81	48.81	48.81	48.81	48.81	48.81	48.81	48.81	48.81	48.47
12	53.24	53.24	53.24	53.15	53.24	53.24	53.24	53.24	53.24	53.24	53.24	53.24	53.24	53.24	53.24	52.59
13	57.68	57.68	57.68	56.82	57.68	57.68	57.68	57.68	57.68	57.68	57.68	57.68	57.68	57.68	57.68	56.08
14	62.12	62.12	62.12	60.23	62.12	62.12	62.12	61.23	62.12	62.12	62.12	61.85	62.12	62.12	61.96	59.55
15	66.55	66.55	66.55	63.45	66.55	66.55	66.55	64.45	66.55	66.55	66.55	65.45	66.55	66.55	66.16	62.79
16	70.99	70.99	70.85	66.60	70.99	70.99	70.99	67.60	70.99	70.99	70.99	68.60	70.99	70.99	70.25	65.61
17	75.43	75.43	75.05	69.41	75.43	75.43	75.43	70.73	75.43	75.43	75.43	71.73	75.43	75.43	74.33	68.33
18	79.86	79.86	79.23	72.21	79.86	79.86	79.86	73.40	79.86	79.86	79.86	74.40	79.86	79.65	78.16	71.04
19	84.30	84.30	82.88	75.01	84.30	84.30	83.90	76.06	84.30	84.30	84.30	77.06	84.30	83.83	81.77	73.68
20	88.74	88.54	86.36	77.73	88.74	88.74	87.57	78.73	88.74	88.74	88.57	79.73	88.74	87.90	85.35	76.11
21	93.17	92.74	89.83	79.96	93.17	93.17	90.84	80.96	93.17	93.17	91.84	81.96	93.14	91.98	88.67	78.32
22	97.61	96.93	93.11	81.92	97.61	97.61	94.11	82.94	97.61	97.61	95.11	83.94	97.33	96.05	91.86	80.34
23	102.03	101.13	96.12	83.70	102.05	102.05	97.25	84.70	102.05	102.05	98.25	85.70	101.48	99.99	94.87	82.26
24	106.23	105.18	98.92	85.40	106.48	106.30	100.39	86.40	106.48	106.48	101.39	87.40	105.55	103.72	97.66	84.12
25	110.43	108.68	101.72	87.05	110.92	109.98	103.54	88.05	110.92	110.92	104.54	89.05	109.63	107.31	100.29	85.76
26	114.62	112.16	104.52	88.68	115.36	113.65	106.43	89.68	115.36	114.65	107.43	90.68	113.70	110.80	102.93	87.30
27	118.78	115.63	107.32	89.93	119.79	117.19	109.10	90.93	119.79	118.19	110.10	91.93	117.78	114.24	105.57	88.69
28	122.85	119.11	110.08	91.08	124.02	120.45	111.76	92.08	124.23	121.45	112.76	93.08	121.81	117.57	108.20	90.00
29	126.93	122.48	112.74	92.12	128.21	123.72	114.43	93.12	128.67	124.72	115.43	94.12	125.54	120.76	110.75	91.26
30	130.77	125.58	115.17	93.21	132.38	126.91	117.09	94.21	133.11	127.91	118.09	95.21	129.23	123.80	113.16	92.48
31	134.39	128.42	117.43	94.27	136.05	130.05	119.42	95.27	137.05	131.05	120.42	96.27	132.76	126.67	115.36	93.61
32	137.96	131.22	119.52	95.33	139.72	133.19	121.47	96.33	140.72	134.19	122.47	97.33	136.22	129.46	117.39	94.71
33	141.44	133.95	121.51	96.40	143.39	136.02	123.40	97.40	144.39	137.34	124.40	98.40	139.63	132.17	119.42	95.75
34	144.91	136.66	123.42	97.46	146.80	138.83	125.19	98.46	147.80	140.46	126.19	99.46	143.08	134.82	121.39	96.66
35	148.29	139.38	125.26	98.33	150.07	141.63	126.91	99.52	151.07	143.13	127.91	100.52	146.34	137.45	123.17	97.33
36	151.54	142.09	127.07	99.00	153.33	144.43	128.60	100.59	154.33	145.79	129.60	101.59	149.56	140.09	124.81	98.00
37	154.75	144.72	128.83	99.67	156.56	147.23	130.25	101.65	157.56	148.46	131.25	102.65	152.65	142.72	126.38	98.66
38	157.82	147.36	130.49	100.34	159.70	150.08	131.89	102.34	160.70	151.13	132.89	103.71	155.60	145.30	127.91	99.29
39	160.58	149.82	132.07	101.01	162.73	152.79	133.52	103.01	163.85	153.79	134.52	104.33	158.41	147.70	129.44	99.92
40	163.30	152.23	133.38	101.67	165.53	155.46	134.85	103.67	166.99	156.46	135.85	104.80	161.20	150.05	130.92	100.56
41	166.01	154.54	134.64	102.34	168.33	157.87	135.95	104.28	170.13	158.87	136.95	105.28	163.92	152.30	132.34	101.15
42	168.70	156.63	135.83	103.01	171.13	159.92	137.04	104.75	173.13	160.92	138.04	105.75	166.60	154.32	133.71	101.72
43	171.34	158.71	137.01	103.68	173.93	161.95	138.13	105.23	175.93	162.95	139.13	106.23	169.27	156.28	135.01	102.27
44	173.97	160.67	138.17	104.25	176.73	163.84	139.23	105.70	178.73	164.87	140.23	106.70	171.95	158.20	136.23	102.72
45	176.61	162.60	139.31	104.82	179.53	165.67	140.31	106.18	181.49	166.68	141.31	107.18	174.57	160.08	137.44	103.15
46	179.25	164.51	140.37	105.38	182.33	167.40	141.37	106.65	184.16	168.40	142.37	107.65	177.15	161.93	138.62	103.58
47	181.88	166.40	141.44	105.94	185.14	169.12	142.44	107.13	186.82	170.12	143.44	108.13	179.72	163.62	139.80	104.01
48	184.44	168.24	142.50	106.41	187.93	170.81	143.50	107.60	189.49	171.81	144.50	108.60	182.21	165.26	140.89	104.41
49	186.88	169.88	143.56	106.80	190.67	172.45	144.56	108.08	192.16	173.45	145.56	109.08	184.60	166.82	141.89	104.80
50	189.28	171.52	144.63	107.19	193.28	174.09	145.63	108.55	194.82	175.09	146.63	109.55	186.93	168.32	142.82	105.19
51	191.60	173.14	145.49	107.54	195.60	175.73	146.69	108.94	197.28	176.73	147.69	109.80	189.14	169.81	143.71	105.58
52	193.75	174.60	146.16	107.88	197.75	177.36	147.75	109.26	199.38	178.36	148.75	109.80	191.11	171.29	144.57	105.97
53	195.80	176.02	146.83	108.18	199.75	178.73	148.82	109.57	201.43	179.73	149.82	109.80	193.08	172.78	145.30	106.33
54	197.83	177.39	147.50	108.41	201.70	179.87	149.50	109.67	203.42	180.87	150.88	109.80	194.95	174.26	146.01	106.68
55	199.84	178.70	148.16	108.65	203.57	180.96	150.16	109.73	205.34	181.96	151.94	109.80	196.85	175.72	146.69	106.91
56	201.77	180.01	148.83	108.76	205.45	182.05	150.83	109.79	207.18	183.05	152.83	109.80	198.69	177.12	147.36	107.13
57	203.70	181.28	149.50	108.85	207.32	183.15	151.50	109.80	208.89	184.15	153.50	109.80	200.52	178.44	147.98	107.35
58	205.58	182.52	150.17	108.91	209.16	184.24	152.17	109.80	210.61	185.24	154.17	109.80	202.27	179.74	148.59	107.54
59	207.38	183.77	150.84	108.97	210.99	185.34	152.84	109.80	212.33	186.34	154.84	109.80	203.94	181.03	149.16	107.73
60	209.01	184.97	151.51	109.04	212.79	186.41	153.51	109.80	214.01	187.41	155.51	109.80	205.52	182.25	149.73	107.91
61	210.59	186.10	152.18	109.10	214.53	187.48	154.18	109.80	215.65	188.48	156.18	109.80	207.07	183.36	150.30	108.05
62	212.18	187.22	152.85	109.16	216.24	188.54	154.85	109.80	217.29	189.54	156.65	109.80	208.62	184.43	150.87	108.16
63	213.76	188.34	153.47	109.22	217.93	189.60	155.52	109.80	218.93	190.60	157.13	109.80	210.14	185.42	151.41	108.28
64	215.30	189.43	154.08	109.28	219.58	190.67	156.19	109.80	220.58	191.67	157.60	109.80	211.63	186.41	151.93	108.39
65	216.77	190.49	154.63	109.34	221.09	191.73	156.81	109.80	222.20	192.73	158.08	109.80	213.11	187.39	152.45	108.51
66	218.25	191.51	155.08	109.40	222.28	192.79	157.38	109.80	223.57	193.79	158.55	109.80	214.60	188.34	152.94	108.60
67	219.73	192.49	155.52	109.46	223.48	193.86	157.94	109.80	224.79	194.86	159.03	109.80	216.09	189.27	153.39	108.67
68	221.20	193.32	155.95	109.52	224.67	194.92	158.50	109.80	225.88	195.92	159.50	109.80	217.57	190.17	153.82	108.74
69	222.63	193.99	156.37	109.58	225.86	195.98	158.98	109.80	226.97	196.98	159.98	109.80	219.01	191.07	154.26	108.81
70	223.97	194.66	156.80	109.64	227.06	196.66	159.45	109.80	228.07	198.05	160.45	109.80	220.43	191.84	154.70	108.88
71	225.21	195.32	157.22	109.70	228.16	197.32	159.93	109.80	229.16	199.11	160.93	109.80	221.81	192.59	155.13	108.94
72	226.41	195.99	157.61	109.76	229.26	197.99	160.40	109.80	230.26	199.99	161.40	109.80	223.15	193.32	155.51	109.01
73	227.61	196.66	158.00	109.80	230.35	198.66	160.88	109.80	231.35	200.66	161.88	109.80	224.42	193.99	155.88	109.08
74	228.81	197.32	158.39	109.80	231.44	199.33	161.35	109.80	232.44	201.33	162.35	109.80	225.63	194.65	156.26	109.13
75	229.99	197.95	158.78	109.80	232.52	200.00	161.83	109.80	233.52	202.00	162.83	109.80	226.77	195.29	156.63	109.16
76	231.16	198.59	159.17	109.80	233.58	200.67	162.26	109.80	234.58	202.67	163.26	109.80	227.86	195.93	157.01	109.18
77	232.33	199.22	159.56	109.80	234.64	201.34	162.57	109.80	235.64	203.34	163.57	109.80	228.90	196.54	157.38	109.20
78	233.50	199.85	159.95	109.80	235.71	202.01	162.89	109.80	236.71	204.01	163.89	109.80	229.91	197.14	157.76	109.22
79	234.64	200.48	160.32	109.80	236.77	202.68	163.14	109.80	237.77	204.68	164.20	109.80	230.90	197.74	158.09	109.24
80	235.78	201.11	160.67	109.80	237.83	203.35	163.38	109.80	238.83	205.35	164.45	109.80	231.88	198.34	158.40	109.26
81	236.90	201.72	161.03	109.80	238.90	204.02	163.51	109.80	239.90	206.02	164.51	109.80	232.87	198.94	158.70	109.28
82	237.94	202.30	161.38	109.80	239.96	204.69	163.57	109.80	240.96	206.69	164.57	109.80	233.83	199.53	158.98	109.30
83	238.97	202.87	161.68	109.80	241.02	205.36	163.63	109.80	242.02	207.36	164.63	109.80	234.76	200.11	159.23	109.32
84	239.90	203.43	161.89	109.80	242.09	206.03	163.69	109.80	243.09	208.03	164.69	109.80	235.68	200.68	159.45	109.33
85	240.78	203.98	162.10	109.80	243.15	206.70	163.75	109.80	244.15	208.70	164.70	109.80	236.59	201.24	159.66	109.34
86	241.61	204.54	162.30	109.80	243.81	207.36	163.81	109.80	245.21	209.36	164.70	109.80	237.48	201.80	159.87	109.36
87	242.30	204.99	162.46	109.80	244.48	207.94	163.87	109.80	246.28	209.93	164.70	109.80	238.23	202.37	160.07	109.37
88	242.96	205.44	162.56	109.80	245.15	208.50	163.93	109.80	247.15	210.40	164.70	109.80	238.91	202.88	160.26	109.39
89	243.62	205.88	162.65	109.80	245.82	209.07	163.99	109.80	247.82	210.88	164.70	109.80	239.59	203.32	160.44	109.40
90	244.28	206.31	162.74	109.80	246.49	209.63	164.05	109.80	248.49	211.35	164.70	109.80	240.28	203.74	160.62	109.42
91	244.93	206.74	162.83	109.80	247.16	210.20	164.11	109.80	249.16	211.83	164.70	109.80	240.95	204.15	160.77	109.42
92	245.58	207.16	162.93	109.80	247.83	210.76	164.17	109.80	249.83	212.30	164.70	109.80	241.60	204.56	160.92	109.43
93	246.22	207.59	163.02	109.80	248.50	211.33	164.23	109.80	250.50	212.78	164.70	109.80	242.26	204.98	161.07	109.43
94	246.85	208.02	163.11	109.80	249.17	211.89	164.30	109.80	251.17	213.25	164.70	109.80	242.92	205.39	161.23	109.44
95	247.48	208.43	163.20	109.80	249.84	212.37	164.36	109.80	251.84	213.73	164.70	109.80	243.58	205.80	161.38	109.44
96	248.11	208.82	163.29	109.80	250.51	212.82	164.42	109.80	252.51	214.20	164.70	109.80	244.24	206.20	161.53	109.45
97	248.71	209.21	163.38	109.80	251.18	213.21	164.48	109.80	253.18	214.68	164.70	109.80	244.90	206.59	161.68	109.45
98	249.29	209.59	163.46	109.80	251.85	213.59	164.54	109.80	253.85	215.15	164.70	109.80	245.56	206.96	161.81	109.46
99	249.86	209.98	163.52	109.80	252.52	213.98	164.60	109.80	254.52	215.63	164.70	109.80	246.19	207.32	161.90	109.46
100	250.44	210.37	163.59	109.80	253.19	214.37	164.66	109.80	255.19	216.10	164.70	109.80	246.80	207.68	161.99	109.46

Appendix B

Rain Intensity (mm/hr)	15	Time in hours				30	Time in hours				45	Time in hours				60	Time in hours			
Roof Area (sq.m.)	Vol/hr	0.5 cu.m.	1 cu.m.	2 cu.m.	3 cu.m.	Vol/hr	0.5 cu.m.	1 cu.m.	2 cu.m.	3 cu.m.	Vol/hr	0.5 cu.m.	1 cu.m.	2 cu.m.	3 cu.m.	Vol/hr	0.5 cu.m.	1 cu.m.	2 cu.m.	3 cu.m.
0.1	0.00135	370.3703	740.7407	1481.481	2222.222	0.0027	185.1851	370.3703	740.7407	1111.111	0.00405	123.4567	246.9135	493.8271	740.7407	0.0054	92.59259	185.1851	370.3703	555.5555
1	0.0135	37.03703	74.07407	148.1481	222.2222	0.027	18.51851	37.03703	74.07407	111.1111	0.0405	12.34567	24.69135	49.38271	74.07407	0.054	9.259259	18.51851	37.03703	55.55555
2	0.027	18.51851	37.03703	74.07407	111.1111	0.054	9.259259	18.51851	37.03703	55.55555	0.081	6.172839	12.34567	24.69135	37.03703	0.108	4.629629	9.259259	18.51851	27.77777
3	0.0405	12.34567	24.69135	49.38271	74.07407	0.081	6.172839	12.34567	24.69135	37.03703	0.1215	4.115226	8.230452	16.46090	24.69135	0.162	3.086419	6.172839	12.34567	18.51851
4	0.054	9.259259	18.51851	37.03703	55.55555	0.108	4.629629	9.259259	18.51851	27.77777	0.162	3.086419	6.172839	12.34567	18.51851	0.216	2.314814	4.629629	9.259259	13.88888
5	0.0675	7.407407	14.81481	29.62962	44.44444	0.135	3.703703	7.407407	14.81481	22.22222	0.2025	2.469135	4.938271	9.876543	14.81481	0.27	1.851851	3.703703	7.407407	11.11111
6	0.081	6.172839	12.34567	24.69135	37.03703	0.162	3.086419	6.172839	12.34567	18.51851	0.243	2.057613	4.115226	8.230452	12.34567	0.324	1.543209	3.086419	6.172839	9.259259
7	0.0945	5.291005	10.58201	21.16402	31.74603	0.189	2.645502	5.291005	10.58201	15.87301	0.2835	1.763668	3.527336	7.054673	10.58201	0.378	1.322751	2.645502	5.291005	7.936507
8	0.108	4.629629	9.259259	18.51851	27.77777	0.216	2.314814	4.629629	9.259259	13.88888	0.324	1.543209	3.086419	6.172839	9.259259	0.432	1.157407	2.314814	4.629629	6.944444
9	0.1215	4.115226	8.230452	16.46090	24.69135	0.243	2.057613	4.115226	8.230452	12.34567	0.3645	1.371742	2.743484	5.486968	8.230452	0.486	1.028806	2.057613	4.115226	6.172839
10	0.135	3.703703	7.407407	14.81481	22.22222	0.27	1.851851	3.703703	7.407407	11.11111	0.405	1.234567	2.469135	4.938271	7.407407	0.54	0.925925	1.851851	3.703703	5.555555
11	0.1485	3.367003	6.734006	13.46801	20.20202	0.297	1.683501	3.367003	6.734006	10.10101	0.4455	1.122334	2.244668	4.489337	6.734006	0.594	0.841750	1.683501	3.367003	5.050505
12	0.162	3.086419	6.172839	12.34567	18.51851	0.324	1.543209	3.086419	6.172839	9.259259	0.486	1.028806	2.057613	4.115226	6.172839	0.648	0.771604	1.543209	3.086419	4.629629
13	0.1755	2.849002	5.698005	11.39601	17.09401	0.351	1.424501	2.849002	5.698005	8.547008	0.5265	0.949667	1.899335	3.798670	5.698005	0.702	0.712250	1.424501	2.849002	4.273504
14	0.189	2.645502	5.291005	10.58201	15.87301	0.378	1.322751	2.645502	5.291005	7.936507	0.567	0.881834	1.763668	3.527336	5.291005	0.756	0.661375	1.322751	2.645502	3.968253
15	0.2025	2.469135	4.938271	9.876543	14.81481	0.405	1.234567	2.469135	4.938271	7.407407	0.6075	0.823045	1.646090	3.292181	4.938271	0.81	0.617283	1.234567	2.469135	3.703703
16	0.216	2.314814	4.629629	9.259259	13.88888	0.432	1.157407	2.314814	4.629629	6.944444	0.648	0.771604	1.543209	3.086419	4.629629	0.864	0.578703	1.157407	2.314814	3.472222
17	0.2295	2.178649	4.357298	8.714596	13.07189	0.459	1.089324	2.178649	4.357298	6.535947	0.6885	0.726216	1.452432	2.904865	4.357298	0.918	0.544662	1.089324	2.178649	3.267973
18	0.243	2.057613	4.115226	8.230452	12.34567	0.486	1.028806	2.057613	4.115226	6.172839	0.729	0.685871	1.371742	2.743484	4.115226	0.972	0.514403	1.028806	2.057613	3.086419
19	0.2565	1.949317	3.898635	7.797270	11.69590	0.513	0.974658	1.949317	3.898635	5.847953	0.7695	0.649772	1.299545	2.599090	3.898635	1.026	0.487329	0.974658	1.949317	2.923976
20	0.27	1.851851	3.703703	7.407407	11.11111	0.54	0.925925	1.851851	3.703703	5.555555	0.81	0.617283	1.234567	2.469135	3.703703	1.08	0.462962	0.925925	1.851851	2.777777
21	0.2835	1.763668	3.527336	7.054673	10.58201	0.567	0.881834	1.763668	3.527336	5.291005	0.8505	0.587889	1.175778	2.351557	3.527336	1.134	0.440917	0.881834	1.763668	2.645502
22	0.297	1.683501	3.367003	6.734006	10.10101	0.594	0.841750	1.683501	3.367003	5.050505	0.891	0.561167	1.122334	2.244668	3.367003	1.188	0.420875	0.841750	1.683501	2.525252
23	0.3105	1.610305	3.220611	6.441223	9.661835	0.621	0.805152	1.610305	3.220611	4.830917	0.9315	0.536768	1.073537	2.147074	3.220611	1.242	0.402576	0.805152	1.610305	2.415458
24	0.324	1.543209	3.086419	6.172839	9.259259	0.648	0.771604	1.543209	3.086419	4.629629	0.972	0.514403	1.028806	2.057613	3.086419	1.296	0.385802	0.771604	1.543209	2.314814
25	0.3375	1.481481	2.962962	5.925925	8.888888	0.675	0.740740	1.481481	2.962962	4.444444	1.0125	0.493827	0.987654	1.975308	2.962962	1.35	0.370370	0.740740	1.481481	2.222222
26	0.351	1.424501	2.849002	5.698005	8.547008	0.702	0.712250	1.424501	2.849002	4.273504	1.053	0.474833	0.949667	1.899335	2.849002	1.404	0.356125	0.712250	1.424501	2.136752
27	0.3645	1.371742	2.743484	5.486968	8.230452	0.729	0.685871	1.371742	2.743484	4.115226	1.0935	0.457247	0.914494	1.828989	2.743484	1.458	0.342935	0.685871	1.371742	2.057613
28	0.378	1.322751	2.645502	5.291005	7.936507	0.756	0.661375	1.322751	2.645502	3.968253	1.134	0.440917	0.881834	1.763668	2.645502	1.512	0.330687	0.661375	1.322751	1.984126
29	0.3915	1.277139	2.554278	5.108556	7.662835	0.783	0.638569	1.277139	2.554278	3.831417	1.1745	0.425713	0.851426	1.702852	2.554278	1.566	0.319284	0.638569	1.277139	1.915708
30	0.405	1.234567	2.469135	4.938271	7.407407	0.81	0.617283	1.234567	2.469135	3.703703	1.215	0.411522	0.823045	1.646090	2.469135	1.62	0.308641	0.617283	1.234567	1.851851
31	0.4185	1.194743	2.389486	4.778972	7.168458	0.837	0.597371	1.194743	2.389486	3.584229	1.2555	0.398247	0.796495	1.592990	2.389486	1.674	0.298685	0.597371	1.194743	1.792114
32	0.432	1.157407	2.314814	4.629629	6.944444	0.864	0.578703	1.157407	2.314814	3.472222	1.296	0.385802	0.771604	1.543209	2.314814	1.728	0.289351	0.578703	1.157407	1.736111
33	0.4455	1.122334	2.244668	4.489337	6.734006	0.891	0.561167	1.122334	2.244668	3.367003	1.3365	0.374111	0.748222	1.496445	2.244668	1.782	0.280583	0.561167	1.122334	1.683501
34	0.459	1.089324	2.178649	4.357298	6.535947	0.918	0.544662	1.089324	2.178649	3.267973	1.377	0.363108	0.726216	1.452432	2.178649	1.836	0.272331	0.544662	1.089324	1.633986
35	0.4725	1.058201	2.116402	4.232804	6.349206	0.945	0.529100	1.058201	2.116402	3.174603	1.4175	0.352733	0.705467	1.410934	2.116402	1.89	0.264550	0.529100	1.058201	1.587301
36	0.486	1.028806	2.057613	4.115226	6.172839	0.972	0.514403	1.028806	2.057613	3.086419	1.458	0.342935	0.685871	1.371742	2.057613	1.944	0.257201	0.514403	1.028806	1.543209
37	0.4995	1.001001	2.002002	4.004004	6.006006	0.999	0.500500	1.001001	2.002002	3.003003	1.4985	0.333667	0.667334	1.334668	2.002002	1.998	0.250250	0.500500	1.001001	1.501501
38	0.513	0.974658	1.949317	3.898635	5.847953	1.026	0.487329	0.974658	1.949317	2.923976	1.539	0.324886	0.649772	1.299545	1.949317	2.052	0.243664	0.487329	0.974658	1.461988
39	0.5265	0.949667	1.899335	3.798670	5.698005	1.053	0.474833	0.949667	1.899335	2.849002	1.5795	0.316555	0.633111	1.266223	1.899335	2.106	0.237416	0.474833	0.949667	1.424501
40	0.54	0.925925	1.851851	3.703703	5.555555	1.08	0.462962	0.925925	1.851851	2.777777	1.62	0.308641	0.617283	1.234567	1.851851	2.16	0.231481	0.462962	0.925925	1.388888
41	0.5535	0.903342	1.806684	3.613369	5.420054	1.107	0.451671	0.903342	1.806684	2.710027	1.6605	0.301114	0.602228	1.204456	1.806684	2.214	0.225835	0.451671	0.903342	1.355013
42	0.567	0.881834	1.763668	3.527336	5.291005	1.134	0.440917	0.881834	1.763668	2.645502	1.701	0.293944	0.587889	1.175778	1.763668	2.268	0.220458	0.440917	0.881834	1.322751
43	0.5805	0.861326	1.722652	3.445305	5.167958	1.161	0.430663	0.861326	1.722652	2.583979	1.7415	0.287108	0.574217	1.148435	1.722652	2.322	0.215331	0.430663	0.861326	1.291989
44	0.594	0.841750	1.683501	3.367003	5.050505	1.188	0.420875	0.841750	1.683501	2.525252	1.782	0.280583	0.561167	1.122334	1.683501	2.376	0.210437	0.420875	0.841750	1.262626
45	0.6075	0.823045	1.646090	3.292181	4.938271	1.215	0.411522	0.823045	1.646090	2.469135	1.8225	0.274348	0.548696	1.097393	1.646090	2.43	0.205761	0.411522	0.823045	1.234567
46	0.621	0.805152	1.610305	3.220611	4.830917	1.242	0.402576	0.805152	1.610305	2.415458	1.863	0.268384	0.536768	1.073537	1.610305	2.484	0.201288	0.402576	0.805152	1.207729
47	0.6345	0.788022	1.576044	3.152088	4.728132	1.269	0.394011	0.788022	1.576044	2.364066	1.9035	0.262674	0.525348	1.050696	1.576044	2.538	0.197005	0.394011	0.788022	1.182033
48	0.648	0.771604	1.543209	3.086419	4.629629	1.296	0.385802	0.771604	1.543209	2.314814	1.944	0.257201	0.514403	1.028806	1.543209	2.592	0.192901	0.385802	0.771604	1.157407
49	0.6615	0.755857	1.511715	3.023431	4.535147	1.323	0.377928	0.755857	1.511715	2.267573	1.9845	0.251952	0.503905	1.007810	1.511715	2.646	0.188964	0.377928	0.755857	1.133786
50	0.675	0.740740	1.481481	2.962962	4.444444	1.35	0.370370	0.740740	1.481481	2.222222	2.025	0.246913	0.493827	0.987654	1.481481	2.7	0.185185	0.370370	0.740740	1.111111
51	0.6885	0.726216	1.452432	2.904865	4.357298	1.377	0.363108	0.726216	1.452432	2.178649	2.0655	0.242072	0.484144	0.968288	1.452432	2.754	0.181554	0.363108	0.726216	1.089324
52	0.702	0.712250	1.424501	2.849002	4.273504	1.404	0.356125	0.712250	1.424501	2.136752	2.106	0.237416	0.474833	0.949667	1.424501	2.808	0.178062	0.356125	0.712250	1.068376
53	0.7155	0.698812	1.397624	2.795248	4.192872	1.431	0.349406	0.698812	1.397624	2.096436	2.1465	0.232937	0.465874	0.931749	1.397624	2.862	0.174703	0.349406	0.698812	1.048218
54	0.729	0.685871	1.371742	2.743484	4.115226	1.458	0.342935	0.685871	1.371742	2.057613	2.187	0.228623	0.457247	0.914494	1.371742	2.916	0.171467	0.342935	0.685871	1.028806
55	0.7425	0.673400	1.346801	2.693602	4.040404	1.485	0.336700	0.673400	1.346801	2.020202	2.2275	0.224466	0.448933	0.897867	1.346801	2.97	0.168350	0.336700	0.673400	1.010101
56	0.756	0.661375	1.322751	2.645502	3.968253	1.512	0.330687	0.661375	1.322751	1.984126	2.268	0.220458	0.440917	0.881834	1.322751	3.024	0.165343	0.330687	0.661375	0.992063
57	0.7695	0.649772	1.299545	2.599090	3.898635	1.539	0.324886	0.649772	1.299545	1.949317	2.3085	0.216590	0.433181	0.866363	1.299545	3.078	0.162443	0.324886	0.649772	0.974658
58	0.783	0.638569	1.277139	2.554278	3.831417	1.566	0.319284	0.638569	1.277139	1.915708	2.349	0.212856	0.425713	0.851426	1.277139	3.132	0.159642	0.319284	0.638569	0.957854
59	0.7965	0.627746	1.255492	2.510985	3.766478	1.593	0.313873	0.627746	1.255492	1.883239	2.3895	0.209248	0.418497	0.836995	1.255492	3.186	0.156936	0.313873	0.627746	0.941619
60	0.81	0.617283	1.234567	2.469135	3.703703	1.62	0.308641	0.617283	1.234567	1.851851	2.43	0.205761	0.411522	0.823045	1.234567	3.24	0.154320	0.308641	0.617283	0.925925
61	0.8235	0.607164	1.214329	2.428658	3.642987	1.647	0.303582	0.607164	1.214329	1.821493	2.4705	0.202388	0.404776	0.809552	1.214329	3.294	0.151791	0.303582	0.607164	0.910746
62	0.837	0.597371	1.194743	2.389486	3.584229	1.674	0.298685	0.597371	1.194743	1.792114	2.511	0.199123	0.398247	0.796495	1.194743	3.348	0.149342	0.298685	0.597371	0.896057
63	0.8505	0.587889	1.175778	2.351557	3.527336	1.701	0.293944	0.587889	1.175778	1.763668	2.5515	0.195963	0.391926	0.783852	1.175778	3.402	0.146972	0.293944	0.587889	0.881834
64	0.864	0.578703	1.157407	2.314814	3.472222	1.728	0.289351	0.578703	1.157407	1.736111	2.592	0.192901	0.385802	0.771604	1.157407	3.456	0.144675	0.289351	0.578703	0.868055
65	0.8775	0.569800	1.139601	2.279202	3.418803	1.755	0.284900	0.569800	1.139601	1.709401	2.6325	0.189933	0.379867	0.759734	1.139601	3.51	0.142450	0.284900	0.569800	0.854700
66	0.891	0.561167	1.122334	2.244668	3.367003	1.782	0.280583	0.561167	1.122334	1.683501	2.673	0.187055	0.374111	0.748222	1.122334	3.564	0.140291	0.280583	0.561167	0.841750
67	0.9045	0.552791	1.105583	2.211166	3.316749	1.809	0.276395	0.552791	1.105583	1.658374	2.7135	0.184263	0.368527	0.737055	1.105583	3.618	0.138197	0.276395	0.552791	0.829187
68	0.918	0.544662	1.089324	2.178649	3.267973	1.836	0.272331	0.544662	1.089324	1.633986	2.754	0.181554	0.363108	0.726216	1.089324	3.672	0.136165	0.272331	0.544662	0.816993
69	0.9315	0.536768	1.073537	2.147074	3.220611	1.863	0.268384	0.536768	1.073537	1.610305	2.7945	0.178922	0.357845	0.715691	1.073537	3.726	0.134192	0.268384	0.536768	0.805152
70	0.945	0.529100	1.058201	2.116402	3.174603	1.89	0.264550	0.529100	1.058201	1.587301	2.835	0.176366	0.352733	0.705467	1.058201	3.78	0.132275	0.264550	0.529100	0.793650
71	0.9585	0.521648	1.043296	2.086593	3.129890	1.917	0.260824	0.521648	1.043296	1.564945	2.8755	0.173882	0.347765	0.695531	1.043296	3.834	0.130412	0.260824	0.521648	0.782472
72	0.972	0.514403	1.028806	2.057613	3.086419	1.944	0.257201	0.514403	1.028806	1.543209	2.916	0.171467	0.342935	0.685871	1.028806	3.888	0.128600	0.257201	0.514403	0.771604
73	0.9855	0.507356	1.014713	2.029426	3.044140	1.971	0.253678	0.507356	1.014713	1.522070	2.9565	0.169118	0.338237	0.676475	1.014713	3.942	0.126839	0.253678	0.507356	0.761035
74	0.999	0.500500	1.001001	2.002002	3.003003	1.998	0.250250	0.500500	1.001001	1.501501	2.997	0.166833	0.333667	0.667334	1.001001	3.996	0.125125	0.250250	0.500500	0.750750
75	1.0125	0.493827	0.987654	1.975308	2.962962	2.025	0.246913	0.493827	0.987654	1.481481	3.0375	0.164609	0.329218	0.658436	0.987654	4.05	0.123456	0.246913	0.493827	0.740740
76	1.026	0.487329	0.974658	1.949317	2.923976	2.052	0.243664	0.487329	0.974658	1.461988	3.078	0.162443	0.324886	0.649772	0.974658	4.104	0.121832	0.243664	0.487329	0.730994
77	1.0395	0.481000	0.962000	1.924001	2.886002	2.079	0.240500	0.481000	0.962000	1.443001	3.1185	0.160333	0.320666	0.641333	0.962000	4.158	0.120250	0.240500	0.481000	0.721500
78	1.053	0.474833	0.949667	1.899335	2.849002	2.106	0.237416	0.474833	0.949667	1.424501	3.159	0.158277	0.316555	0.633111	0.949667	4.212	0.118708	0.237416	0.474833	0.712250
79	1.0665	0.468823	0.937646	1.875293	2.812939	2.133	0.234411	0.468823	0.937646	1.406469	3.1995	0.156274	0.312548	0.625097	0.937646	4.266	0.117205	0.234411	0.468823	0.703234
80	1.08	0.462962	0.925925	1.851851	2.777777	2.16	0.231481	0.462962	0.925925	1.388888	3.24	0.154320	0.308641	0.617283	0.925925	4.32	0.115740	0.231481	0.462962	0.694444
81	1.0935	0.457247	0.914494	1.828989	2.743484	2.187	0.228623	0.457247	0.914494	1.371742	3.2805	0.152415	0.304831	0.609663	0.914494	4.374	0.114311	0.228623	0.457247	0.685871
82	1.107	0.451671	0.903342	1.806684	2.710027	2.214	0.225835	0.451671	0.903342	1.355013	3.321	0.150557	0.301114	0.602228	0.903342	4.428	0.112917	0.225835	0.451671	0.677506
83	1.1205	0.446229	0.892458	1.784917	2.677376	2.241	0.223114	0.446229	0.892458	1.338688	3.3615	0.148743	0.297486	0.594972	0.892458	4.482	0.111557	0.223114	0.446229	0.669344
84	1.134	0.440917	0.881834	1.763668	2.645502	2.268	0.220458	0.440917	0.881834	1.322751	3.402	0.146972	0.293944	0.587889	0.881834	4.536	0.110229	0.220458	0.440917	0.661375
85	1.1475	0.435729	0.871459	1.742919	2.614379	2.295	0.217864	0.435729	0.871459	1.307189	3.4425	0.145243	0.290486	0.580973	0.871459	4.59	0.108932	0.217864	0.435729	0.653594
86	1.161	0.430663	0.861326	1.722652	2.583979	2.322	0.215331	0.430663	0.861326	1.291989	3.483	0.143554	0.287108	0.574217	0.861326	4.644	0.107665	0.215331	0.430663	0.645994
87	1.1745	0.425713	0.851426	1.702852	2.554278	2.349	0.212856	0.425713	0.851426	1.277139	3.5235	0.141904	0.283808	0.567617	0.851426	4.698	0.106428	0.212856	0.425713	0.638569
88	1.188	0.420875	0.841750	1.683501	2.525252	2.376	0.210437	0.420875	0.841750	1.262626	3.564	0.140291	0.280583	0.561167	0.841750	4.752	0.105218	0.210437	0.420875	0.631313
89	1.2015	0.416146	0.832292	1.664585	2.496878	2.403	0.208073	0.416146	0.832292	1.248439	3.6045	0.138715	0.277430	0.554861	0.832292	4.806	0.104036	0.208073	0.416146	0.624219
90	1.215	0.411522	0.823045	1.646090	2.469135	2.43	0.205761	0.411522	0.823045	1.234567	3.645	0.137174	0.274348	0.548696	0.823045	4.86	0.102880	0.205761	0.411522	0.617283
91	1.2285	0.407000	0.814000	1.628001	2.442002	2.457	0.203500	0.407000	0.814000	1.221001	3.6855	0.135666	0.271333	0.542667	0.814000	4.914	0.101750	0.203500	0.407000	0.610500
92	1.242	0.402576	0.805152	1.610305	2.415458	2.484	0.201288	0.402576	0.805152	1.207729	3.726	0.134192	0.268384	0.536768	0.805152	4.968	0.100644	0.201288	0.402576	0.603864
93	1.2555	0.398247	0.796495	1.592990	2.389486	2.511	0.199123	0.398247	0.796495	1.194743	3.7665	0.132749	0.265498	0.530996	0.796495	5.022	0.099561	0.199123	0.398247	0.597371
94	1.269	0.394011	0.788022	1.576044	2.364066	2.538	0.197005	0.394011	0.788022	1.182033	3.807	0.131337	0.262674	0.525348	0.788022	5.076	0.098502	0.197005	0.394011	0.591016
95	1.2825	0.389863	0.779727	1.559454	2.339181	2.565	0.194931	0.389863	0.779727	1.169590	3.8475	0.129954	0.259909	0.519818	0.779727	5.13	0.097465	0.194931	0.389863	0.584795
96	1.296	0.385802	0.771604	1.543209	2.314814	2.592	0.192901	0.385802	0.771604	1.157407	3.888	0.128600	0.257201	0.514403	0.771604	5.184	0.096450	0.192901	0.385802	0.578703
97	1.3095	0.381825	0.763650	1.527300	2.290950	2.619	0.190912	0.381825	0.763650	1.145475	3.9285	0.127275	0.254550	0.509100	0.763650	5.238	0.095456	0.190912	0.381825	0.572737
98	1.323	0.377928	0.755857	1.511715	2.267573	2.646	0.188964	0.377928	0.755857	1.133786	3.969	0.125976	0.251952	0.503905	0.755857	5.292	0.094482	0.188964	0.377928	0.566893
99	1.3365	0.374111	0.748222	1.496445	2.244668	2.673	0.187055	0.374111	0.748222	1.122334	4.0095	0.124703	0.249407	0.498815	0.748222	5.346	0.093527	0.187055	0.374111	0.561167
100	1.35	0.370370	0.740740	1.481481	2.222222	2.7	0.185185	0.370370	0.740740	1.111111	4.05	0.123456	0.246913	0.493827	0.740740	5.4	0.092592	0.185185	0.370370	0.555555

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