*Journal of Water and Land use Management*
*ISSN: 0973-9300, Volume 16, Issue 1*

# Rainwater Harvesting in Samoa: A Case in Point

**Tuiloma Susana Taua'a**

*Received:* ***15 December 2017***
*Reviewed and Accepted:* ***03 January 2018***
*Published:* ***24 January 2018***

**Abstract** RWH is the process of collecting, storing and using rain water as a primary or supplementary water source. The practice has been used throughout history as a water conservation measure, particularly in regions where other water resources are scarce or difficult to access. Rainwater usage is promoted in the Pacific to aid in meeting Sustainable Development Goal (SDG) number 6 of sustainable access to safe drinking water. This practice is particularly important in places like Tuvalu, Tokelau and the smaller outer islands in Tonga and the Cook Island group characterized by average moderate rainfall and lengthy dry spells. Apia Urban Area (AUA) and North West Upolu (NWU) are rapidly expanding settlement areas on Upolu Island. Urban demand on the reticulated water supply is increasing with population growth in these areas. Seventy-nine (79) percent of households in the AUA source their drinking water from metered water taps and a corresponding 73.6% of NWU households also rely on metered water. It should be practical in a small country like Samoa to make RWH mandatory, because the technology needed for RWH is considered low-cost but high-impact in relation to social, economic and environmental impacts to the household and the community be it the village, rural or urban area, or country-wide. Household rainwater tanks can provide assurance for an alternative and independent water supply when the main supply is interrupted.

**Keywords** Water resource; urbanization; drinking water; sustainability

**Tuiloma Susana Taua'a (✉)**
*Social Science Department, Faculty of Arts, National University of Samoa, Apia*

## Introduction

Water is a fundamental resource to life and wellbeing of human society. Yet, millions of people worldwide suffer from lack of water. The problems of fresh water resource conservation have been well documented (Van der Bruggen, Borghgraef and Vinckier, 2010; Duncan 2011) but there are still many factors that compromise the quantity and quality of water supply sources in many developing countries. In the case of Samoa, rapid urbanization, deforestation, destruction of wetlands, agricultural development and water leakage from water distribution systems are causal factors underlying the country's water problems. To aid Samoa's efforts to conserve and manage its waning water resources, Rain Water Harvesting (RWH) is identified and explored in this study as a viable solution to meet Apia's escalating water demand. The problem though, is the lack of hard evidence to convince the proper authorities of the benefits of RWH beginning at the household level and stair casing into a nation-wide practice. The study sets out to answer three important questions (i) is RWH environmentally, socially and economically feasible? (ii) should it be mandatory for all newly constructed houses to adhere to water saving designs and products such as water efficient devises and RWH fittings? and (iii) what are the prevailing beliefs and views among the average Samoan household in relation to RWH practices?

## Literature Review

Rainwater as a renewable resource, its availability in space (specific location) and time (different periods of the year) is limited by climate, geographical and physical conditions as well as the type of technology used for harvesting. Furthermore, rainwater has always been harvested as a low –volume but high quality source of water in the Pacific islands and elsewhere in the developing world. Since the nineteenth century, its use in industrialized countries has received less attention than more technically oriented centralized water systems (Latham& Schiller1984). In recent years, researchers and policy makers have shown renewed interest in water use strategies due to rising water demand and increased interest in water resources conservation. In addition, the costly operation and maintenance of conventional water supply systems has drawn attention to alternative, affordable and easily maintained systems such as roof water collection systems. Rainwater harvesting can be divided into large, medium, and small scale systems. Large scale systems involve the collection of flood water for irrigation and ground water recharge, whereas medium scale RWH involve the collection of water from rock outcroppings or large impervious constructed surfaces such as dams. Small scale RWH are roof collected rainwater channeled into small (500 liters) to large (10,000 liters) tanks for storage.

Rainwater is collected by constructing large catchment and storage facilities to store and distribute rainwater on small islands can be an expensive exercise compared to small scale household rainwater collection from all or part of the roof

and storing it in small to medium sized tanks and containers. Further, RWH is a renewable resource with minimal environmental impact, requires little or no energy for extraction of the resource, requires minimum transportation, and the labor, material and spare parts can be sourced locally (Kallren 1993).

Similarly, the practice of rainwater harvesting plays a provisioning, regulating and cultural function in the overall ecosystems services of a place or region (UNEP 2009:4). For example, the provisioning role of RWH is evident in increasing the availability of water for livestock and poultry whereas its regulating function can be seen in the reduction of fast flows of water and the incidence of flooding and soil erosion on low lying areas. The cultural functions of RWH are manifested in the spiritual and aesthetic values attached to water, particularly in creating green, lush landscapes

## Making the Case for Rainwater Harvesting

Apia Urban Area (AUA) and North West Upolu (NWU) are rapidly expanding settlement areas on Upolu Island. Urban demand on the reticulated water supply is increasing with population growth in these areas. Seventy-nine (79) percent of households in the AUA source their drinking water from metered water taps and a corresponding 73.6% of NWU households also rely on metered water (Samoa Bureau of Statistics 2012:89). And with climate change and forecasted drought periods will further compound the water stress caused by urbanization.

With rainfall of sustainable volume and good quality (3000mm per annum in the Samoa group), coupled with a growing demand on the urban water supply, RWH is increasingly considered as a supplement to the main water supply (MNRE 2012; SOPAC 2009). This idea is flagged in this study as an urban water management strategy to ease the demand on reticulated water supplies particularly during the dry season. Further, the household unit is the target group for RWH in this study for several reasons. First, household water harvesting practices can be performed by individuals, even children, can be tasked with ensuring that containers for water collection and storage are readily available during the rainy season for the purpose of RWH. Second, the technologies available for household RWH are simple and cheap (roof top collection and storage in above ground water tanks) and benefit the entire household and communities. Third, selling the idea of RWH to the 'household' is an important do-it-yourself-green solution to Apia's emerging water shortage problem in the dry season, where RWH provides a more continuous and reliable access to clean water for domestic uses. Promoting RWH at the household level entails the active participation and ownership by the household of RWH systems and technologies that will guarantee the long term sustainability of RWH given the sense of responsibility is encouraged among the household. And if RWH was extended as part of a collective village/community project the same attitude of ownership and responsibility with RWH at the household level is extended to community owned assets (SOPAC 2004:5).

Many other supporting arguments for RWH have been researched and publicized (SOPAC 2004; 2009) but seem to have been overlooked by the local

water authority. For example, in areas of inadequate groundwater supply, or lacking surface water flows, RWH provides a practical solution. Likewise, RWH reduces surface water runoff into storm drains where in many Pacific Island towns and cities, urban drainage is either inadequate or absent and the incidence of urban flooding has become a frequent occurrence in many of these towns such as Apia, Suva and Nukualofa.

Furthermore, RWH is a simple solution to the multiple water challenges identified in the country national water policy. Poor water quality, competing and conflicting demands for resources by consumptive and non-consumptive users, lack of community understanding and appreciation of responsible water management and insufficient knowledge and understanding of water resources nationwide are examples of critical water resources challenges that the responsible Ministry have yet to address in their quest to ensure 'community access to water of suitable quality and appropriate quantities to meet all reasonable health, environmental, and economic development needs' (Ministry of Natural Resources and Environment 2008:17).

## Conceptualizing Rainwater Harvesting

The practice of collecting and storage rainwater in addition to the reticulated water supply is best conceptualized in the Sustainable Livelihood Approach (SLA). The essence of SLA rests with its systemic and adaptive approach that links wellbeing, sustainability and empowering processes (example participation, gender neutral and good governance [water governance]) (Petersen & Pedersen 2010). Underpinning the SLA are livelihood assets made up of human, natural, financial, social and physical capital. These are the assets people rely on to produce their livelihood outcomes. People's livelihood outcomes depend on the strategies they employ and how they utilize the assets within their control. A case in point to illustrate is the increased usage of rain water that is collected and stored to irrigate farm lands thereby reducing the pressure on forests, grazing lands, wetlands and other fragile ecosystems (Barron 2009:26). Given the study explores RWH at the household level, the practice of RWH is one of many strategies adopted by individuals and households to ensure its wellbeing, particularly under natural stress and shocks such as extremely dry and drought conditions. Focusing RWH at the household unit is a 'soft path' approach to address the issue of water security, emphasizing the importance of using community scale and environmentally sustainable approaches such as household RWH as opposed to large scale centralized infrastructure (Cain 2014:149).

## Methodology

A number of methods were used to collect the data and information to answer the study questions. First, a stakeholder consultation with the Plumbers Association

and plumbing trades instructors to gauge the do-ability of RWH. The focus of the discussion was in relation to the existing building code, costs to the average Samoan household, and the relevance of the idea in response to the global issues of climate change and the fresh water crisis (Srinivasan, Lambin, Gorelick, Thompsen and Rozelle 2012) in addition to meeting the Sustainable Development Goals of access to clean drinking water for all. The second method consists of questionnaires with open and closed ended questions that were entrusted to the participating households for their responses. Focus group interviews was an additional method adopted to enable a more in depth and face to face discussion and follow up of key household responses as stated in the survey questionnaires.

## *Survey questionnaire*

Thirty households from the rural, urban and suburban Apia will be required to complete a questionnaire comprising of questions related to the household bio data, their views on the idea and practice of RWH, costs related to RWH, savings on household water bills and household water use are examples of questions explored in the questionnaire. The responses and findings from the questionnaire will determine the questions asked in the focus groups.

## *Focus group interviews*

One focus group session will be conducted with the head of the household (HH) to clarify the responses in the questionnaires and to debate the advantages and disadvantages of RWH. The focus group will help to clarify and reaffirm the themes identified in the questionnaire analysis. The second focus group will serve as the forum to debate a policy statement for RWH at the national level particularly in relation to the issue of making RWH mandatory.

## *Participants and recruitment*

Thirty households from rural and urban villages of Apia together with members of the Plumbers Association of Samoa (PAS) and plumbing instructors (APTC or NUS) will participate in the study. There are 10 rural households (Vailoa and Lalomanu Aleipata) and 10 urban households (Vaivase-uta and Vaivase-tai) who were pre-selected and consulted based on the criteria that they practice RWH as evident in their ownership of small (less than 2000L) to medium (2000 to 5000L) size water tanks used to store rainwater collected from the roof of the family house in addition to the reticulated water supply. Another 10 households from around suburban Apia (Taufusi, Palisi) make up the third cohort of water users that rely completely on their reticulated water supply.

## *Latest Water & Sanitation Statistics*

Table 1 summarizes the latest data from the Samoa Bureau of Statistics in relation to Water and Sanitation key variables such as household main source of drinking water, ownership of water tanks, size and type of tank as enumerated in the 2016 Census Survey. This latest data provides the 'big picture' to situate RWH data collected from this case study.

**Table 1** Selected National Data on Water & Sanitation 2016.

| Variables | Number of Households |
|---|---|
| Total Number of Household Enumerated | 28862 |
| Metered Water (Samoa Water Authority) | 18013 |
| Non-metered water (Samoa Water authority) | 2226 |
| Total household who own tank | 6474 |
| Type of tank –concrete | 2490 |
| Type of tank-Plastic | 3984 |
| Total household who own tank by size: | |
| 500 liter | 744 |
| 1000 liter | 1204 |
| 3000liter | 1802 |
| 5000 liter | 1593 |
| 10000 liter | 1072 |
| Others | 36 |
| Not Stated | 23 |

Source: Samoa Bureau of Statistics Census Brief, 2017:62

Table 1 indicates a selection of the latest data collected by the Samoa Bureau of Statistics in relation to Water and Sanitation in Samoa. A total of 28862 households were enumerated in the 2016 Census, and 18013 or 62.4 percent of households have metered water compared to 7.7 percent (2226) of households with non-metered water. Of the total number of households counted (28862), only 22.4 percent (6474) own a water tank. Ideally, every household should own at least a small (500 liter) sized tank as a back up to the main water supply. According to 93.3 percent of the study sample (28 households), owning a water tank is a good idea (manatulelei), if only the government is prepared to subsidize the price of water tanks available to households especially for low income households. Even the urban households with reticulated water supply only, concur that owning a water tank is indeed a good idea and an important household asset. This is a sensible idea if RWH was mandatory.

## Result and Discussion

Twenty out of thirty (66.7 percent) of the households surveyed practice RWH as evident in the installation and usage of the Roto polyethylene rainwater tanks that vary in size from 500 liters to the largest at 5000liters. For the rural households, reticulated water supply is the main source of drinking water whereas 8/10 (80 percent) of urban households with reticulated water supply and RWH products depend on bottled water as their main source of drinking water. Likewise, (70 percent) of households with reticulated water supply rely on bottled water as their main source of drinking water.

**Table 2** Summary of Household Profiles

| Variables | Rural Households: RW Tanks & Reticulated Water Supply | Urban Households: RW Tanks & Reticulated Water Supply | Urban Households: Reticulated Water Supply Only. |
|---|---|---|---|
| Number of people in The household[range from] | 4 to 11 | 6 to 9 | 2 to 12 |
| Number of Households surveyed | 10 | 10 | 10 |
| Age Range of people In the household | 18 months to 83 years. | 2 to 76 years. | 5 to 84 years. |
| Main Drinking Water Source? | Reticulated Water Supply for all 10 households | Bottled Water = 8 households.<br>Reticulated water supply= 2 households | Bottled water=7 households.<br>Reticulated water supply=3 households |
| Size of RWH tank | 1000 to 3000 liter | 500 to 5000 liter | none |

The explanations for urban households' reliance on bottled water for drinking purposes relates to the following reason(s) as stated by some head of household and other household members in the interviews:

'just to be on the safe side, we don't trust water from the tap; prevention is better than cure'(44-year-old male)

'do not really trust our water, plus our house is more than 30 years old, I think the plumbing is rusty…' (68-year-old female, head of household)

'my older children who visited from overseas said that we should not be drinking water from the tap, and if we do, then we should boil our water first…they introduced us to buying and refilling our water from the shop' (75-year-old male, head of household)

'we have young children, they are very vulnerable to diarrhea and the doctor said it could be the water, so we buy our water from Apia Bottling, it is $6.00 for a refill…' (39-year-old female)

The majority of urban households in the study sample that have access to reliable water supply (water tanks and reticulated water supply) rely on bottled water for drinking purposes. It was gleaned from the informal talanoa sessions and questionnaires that there is some element of doubt in the cleanliness of the water for drinking purposes. Otherwise, the rest of the households' water requirements for washing, cleaning, cooking and flushing are met by both reticulated water and RWH products.

As for the rural households, piped water provides the main source of drinking water. There is a general consensus among the rural respondents that their reticulated water is generally clean and safe to drink. Moreover, RWH through the proper installation of rainwater tanks, is a recent act in the last 10-15 years, although the practice of collecting rainwater using barrels, gallons and other large containers have always been in existence. Rainwater collected in tanks double as a water reserve when the reticulated water supply is reduced or rationed during the dry season. Sixty percent of rural households with properly installed rainwater tanks reported that the water tanks were always part of the household plans for home improvement given some very unpleasant experience they have had with unreliable water supply in the past. Interestingly, only 10 percent (or 2 out of 20 households) have properly installed booster water pumps that automatically switch on to pump water when needed. The remaining 90 percent of households with installed water tanks simply collect and store water in the tanks, and when the need arises, buckets and other containers are used to transport water from the tanks for use in doors or elsewhere. The costs of a water pumping and filtering system, excluding the costs of electricity or gas, depending on the type of water booster pump, deterred the remaining households from installing water pumping devices.

As for urban households with reticulated water supply only, four households (4 out of 10) reported through 'talanoa' with the heads of the households, that they collect rainwater in large 44 galleons and medium – sized buckets and or other containers particularly during the heavy rainy season when the reticulated water supply is either rationed or turned off indefinitely. Thirty percent (3 out of 10) of the urban households with reticulated water supply were keen to own a water tank if it was affordable. Essentially, RWH is a common practice among the majority of households, particularly at times when the reticulated water supply is under threat.

**Table 3** Household Motives for RWH

| Stated Reasons for RWH | Rural Households: RW Tanks & Reticulated Water Supply [10] | Urban Households: RW Tanks & Reticulated Water Supply [10] | Urban Households: Reticulated Water Supply Only. [10] |
|---|---|---|---|
| To aid with the water bill | 4 households | 6 households | |
| Unreliable piped water | 7 households | 5 households | |
| Reduce flooding to other parts of the land/property | 1 | 3 households | |
| To supplement water for the laundromat small business. | | 1 household | |
| Part of proposed family owned car washing business | | 1 household | |
| So that we are not totally reliant on the Samoa Water Authority. | | 1 household | |

Table 3 summarizes the motives for collecting rainwater as stated by the households with installed rainwater tanks.The motivating factors for RWH were predominantly of a social- economic nature. Other useful benefits of RWH were only evident after the water tanks have been installed. For instance, three rural households were given priority in the distribution of vegetable seedlings from the village farming project based on their ownership of water tanks. Vegetable farming requires a lot of watering, and to ensure the sustainability of the project, certain water requirements ought to be met by the participating village households, hence the households with existing rain water tanks were given priority. Adding value to the existing property is another advantage of having a properly installed RWH system, as stated by one head of household as he was contemplating renting out one of the buildings on his property. Extended 'talanoa' sessions with five urban households that practice RWH indicated a certain degree of eco-environmental appreciation of harvesting rainwater to meet the bulk of their household needs. Two urban households resolved to RWH as a means of managing the rapid flow of excess rain water from the main family home located on higher ground from flooding the families' smaller rental units built on the lower slopes. While modern RWH started off as a response to the often disrupted water supply from the government reticulated water supply, a more multi-dimensional approach to RWH is envisaged from this study.

## *The Economic Dimension of RWH*

Installing tanks to collect rainwater was a household initiative funded by the household. Four households (2 rural and 2 urban) were asked to carry out a simple exercise to map out the cost of installing their RWH system to gauge some idea of the costs involved to enable the researcher to make an economic analysis of the benefits of RWH to the household. It is important to point out, that in the context of this study (small and family/household based) the economic measures of hedonic price methods to assess the real-estate value of RWH or Life Cycle Cost (the sum of acquisition cost and ownership cost of a product [in this case the water tank] over its life cycle) are complex methods that are best reserved for a nationwide study of the water and energy sector. Cost is the single inhibitor of installing RWH systems as informally reported by the urban households with reticulated water supply only. The results of the 'costing' exercise as mapped out by the head of households of the four households are presented in Table 4.Initial investment and maintenance costs are the two main types of costs associated with RWH.

The cost of installing a simple RWH system as indicated by the four households can be fairly high for a low income country with a minimum wage of $2.37 an hour. Financing the purchase and installation of RWH tanks were borne by the employed household members through personal loans, or funded by family members overseas. 'It is a one-off, expense that we had to bear, but the long term benefit is obvious…save time travelling to fetch water from the District Hospital water tank, and there is always water for our vegetable garden, that is very important' (Rural Head of Household #1).The costs for maintenance such as clearing the rain gutters require manual labor, they may be minimal, but if gutters are neglected over long periods of time, leaves and debris can interfere with the process of collecting and transmitting water to the downspout pipe and into the collection tanks. On a closer observation of the installed rainwater conveyance systems (gutters and drain/downspout pipes) not a single household in the study sample with RWH systems (both urban and rural) have a complete rainwater conveyance system that captures rainwater from all the four sides and corners of the roof top surface that function as the catchment area. When queried about the absence of a complete conveyance system, two rural households, cited the 'cost' of fittings as a major obstacle in installing the full conveyance system.

## *RWH and potential savings for the household*

Five households (2 rural & 3 urban) with RWH systems and reticulated water supply, were very positive about the cost saving impacts of RWH, based on the household assumption that the more water they collect and save, the more money they save. The households identified monies saved by comparing their July-December 2016 and July-December 2017 water bills. For one of the rural households, they paidan average of $58.00 per month in 2016 compared to $46.00 for the same period in 2017. Although savings were minimal, the fact that savings can

be achieved encouraged a positive attitude towards water management through RWH practices. Data limitations and difficulty in quantifying the value of ongoing maintenance expenses to RWH systems at the household level further complicates efforts to predict realistic water and financial savings to the household.

**Table 4** Household Investment Costs for RWH

| Household (Both RW tanks & Reticulated Water Supply) | Water Price (Reticulated Water) | Cost of tank (Size)& fittings | Cost of installation | Maintenance |
|---|---|---|---|---|
| Rural household #1 | 0.5000 per unit (Cubic Meters) | $899.00 (1000L) + $500.00 fittings | $200.00, some food and 2 fine mats. | Clearing gutter |
| Rural household # 2 | 0.5000 per unit (cubic Meters) | $1,800 (3000L) +$680.00 fittings | $180.00, food, & alcohol. | None so far |
| Urban household #3 | 0.5000 per unit (cubic Meters) | $3,500(5000L) + $800.00 | $400.00 and food | Minor repairs to downspout pipe. |
| Urban household #4 | 0.5000 per unit (cubic Meters) | $1200.00(1000L) including fittings | $300.00 | none |

## *Should RWH be mandatory?*

Given the threats of global warming and shifting rainfall trends associated with the El Nino-Southern Oscillation (ENSO) phenomenon, it is imperative that RWH should be made mandatory particularly for small island states that stand vulnerable to adverse impacts of climate change such as prolonged drought events, or excessive precipitation and coastal flooding episodes. Plumbing instructors and members of the Plumbing Association of Samoa, concur that RWH should be mandatory for many reasons. First, it makes economic sense to collect and store rain water as it translates into savings for the household budget. Second, it is a well-known fact that RWH reduces surface runoff (Mallin, Johnson & Ensign 2008:476) particularly storm runoff a major contributor to non-point pollution. As such, the Plumbers Association of Samoa (PAS) are advocating for mandatory RWH to reduce the adverse impacts of surface runoff and by the same token improve on household water reserves for the dry season. To make RWH mandatory requires a change in the existing regulations governing the building code and practices in Samoa. In countries like Australia, efforts have been undertaken by the different states (Victoria, South Australia, Sydney and New South Wales, Gold Coast, Queensland) to ensure that newly built houses comply with the latest energy and water efficient products, such initiatives are backed by legislation. PAS is advocating for a similar approach that calls for collaboration across the Ministries

of the Natural Resources and Environment, Works, Transport and Infrastructure and other relevant government authorities, such as the Samoa Water Authority to rework National master plans to promote and support RWH policy.

Moreover, RWH is a site-specific source control that satisfies both indoor and outdoor demands for water. While it is beyond the scope of this study to carry out a hydrologic analysis to quantify the ecosystem services benefits of RWH, but anecdotal evidence from the focus group sessions with PAS members strongly indicate valuable contributions of RWH to small garden irrigation, and supplementing water for laundromat and car washing businesses. Significant benefits to stormwater management can also be achieved through the use of rainwater tanks. Thus, it is socially and economically desirable to make RWH mandatory, at least beginning with every new building both private and public that will be built from 2020 onwards.

A whole of house approach is one way of lending support towards efforts for mandatory RWH. This approach calls for more integrative cooperation between home designers /builders and plumbers to ensure that RWH extend beyond the simple practice of collecting rainwater to meet the household's water demands to include the recycling of grey water for flushing and irrigation. 'It is not a new idea, it is already a practice in some Asian countries, with water deficit problems, like Taiwan where greywater is filtered and recycled for flushing purposes' (Vice President PAS personal communication, February 2, 2018). It is important to note, that RWH is just one of many components of water resources management that begins with the management and conservation of the watershed, river corridors and river basins to coastal ecosystems as embraced in the principles of Integrated Water Resources Management (IWRM). IWRM promotes the coordinated development and management of water, land and related resources to maximize the resultant economic and social welfare of society in a sustainable manner without compromising the sustainability of these critical ecosystems (Global Water Partnership 2017).

It should be practical in a small country like Samoa to make RWH mandatory, because the technology needed for RWH is considered low-cost but high-impact in relation to social, economic and environmental impacts to the household and the community be it the village, rural or urban area, or country-wide. Household rainwater tanks can provide assurance for an alternative and independent water supply when the main supply is interrupted. RWH provides a renewable supply of fresh water through natural precipitation. What is required for this low-cost technology is a collection system (roof-top), gutters with brackets and downspout pipes to convey the water and a storage system (tank or cistern). And these elements must be factored into the building code, and building permits should only be granted upon satisfying RWH requirements.

## *Derived themes from focus group discussions*

**Contamination of rainwater**

Rainwater is collected mainly from the roof tops and then channeled /directed into water tanks of various sizes. Roof top rain water can provide good quality water if the roof top is clean. Otherwise rainwater can be contaminated by rust from metallic corrugated iron roofs or some other sources such as bird droppings on the roof. The main source of contaminants identified in the study are derived from bird droppings and debris trapped on the roof. It is also possible that rainwater may dissolve some heavy metals that are present in the materials used to construct roof tops such as galvanized iron used for roof tops as well as galvanized iron water tanks.

**Reliable and Convenient**

The supply of rainwater is always available every time it rains. All we need to do is ensure that it is properly collected and stored. Installing our rainwater tank is a time saving investment and a very convenient and useful 'family asset', compared to our flat screen television that is using up our cash power. (64-year-old male from Vailoa).

**Household water sharing**

One of the problems identified by three urban households (2 with rainwater tanks and 1 with reticulated water supply only) is having to share their water with the neighbors since the latter's water has been disconnected by the Samoa Water Authority due to non-payment of outstanding water bills. This practice of water sharing has been ongoing for almost 12 months, and there seems to be no effort on the part of the neighbors to pay their outstanding water bill and have their water reconnected. The households that are providing free water for their neighbors believe that their 'generosity and neighborly' kindness is being exploited by their neighbors which could lead to strained relations. This raises issues related to the cost of water and the ability of families to pay for their water, an issue that lends support to RWH as a means of supplementing household water demands to ease sole reliance on the reticulated water supply.

**Special needs of dependent household members**

Having young children and elderly (matua–tausi) persons in the household is another important reason for the household to install water tanks. Three rural households and two urban households indicated that the daily needs (hygiene) of caring for the young and especially the elderly (more so when bedridden) calls for an uninterrupted supply of water. Hence, one of the reasons for the household decision to purchase and install a rainwater tank. The specific water needs of the elderly tend to be overlooked or sometimes subsumed under the general water needs of the household. It is important to point out, that access to clean water among other things such as appropriate food and sanitation are critical needs of the vulnerable

members of the household particularly in an emergency as was demonstrated in the 2009 tsunami and cyclone Gita in 2018.

**Water literacy among household members**

This was one recurring statement from Plumbing lecturers/instructors and PAS members consulted in the formal and informal talanoa sessions to explore the issue of RWH and the general attitudes of many people towards water be it managing water at the source or when it is delivered into homes. Water should be everybody's business, and water harvesting should not be confined to the household, in fact, it should be a community wide agenda. Water literacy is understanding and acting on all aspects of water conservation, management, and usage (social, economic, agriculture, leisure). At the household unit, for example, water literacy can include the understanding and acceptance of applying water saving devices such as dual flush toilets and water efficient shower heads or faucets. And in the absence of water efficient devices, then simple water conservation actions in the home ought to be promoted, such as plugging sinks and wash basins when washing dishes, turning off the tap while brushing teeth and taking shorter showers (Taua'a 2014:15). There is a need to step up efforts to raise awareness about water conservation, and it ought to be an ongoing aspect of the water resources management campaign by the Water and Sanitation Sector of the Ministry of Natural Resources and Environment.

**RWH and livelihoods**

Climate change and the projected shifting of rainfall patterns can have an adverse impact on small farming families particularly during the dry season. Two rural households in the study are farming families, one with a sizable mixed vegetable farm (bok choi, cucumbers, round cabbage, chili, egg plants, okra) and the second household raise livestock (cattle and pigs). Cultivating water sensitive cash crops (vegetables) is a household decision premised on profitable earnings from selling the vegetables (major supplier) to the surrounding beach fale tourism operations in the area. The short growing season (5 to 6 weeks) for some vegetables (bok choi) makes it an ideal produce earning the family a stable income. Moreover, RWH has the lowest salt content compared to other types of water (river) available for watering the vegetables. Owning and accessing RWH system/technology has led to changes in cropping selection such as the introduction of new types of vegetables (okra and new bokchoi varieties), to boost their household income.

Livestock farmers indicated that aside from their household water needs, their livestock are also important given the wealth (tamaoaiga) and source of income (tupemaua) for the family is measured and derived from their cattle (43 head count) and pigs (2 lactating sows ,9 fattening pigs, 6 weaners). All animals should have continuous access to a suitable water supply of fresh drinking water every day. Ideally, the lactating sows need 20 liters of water per day, and cattle, espe-

cially the cows with their young calves, need 40 to 50 liters/day. To ensure that the cattle are provided with adequate water on a daily basis, the family built a small 5 meters by 8meters' open house with a corrugated iron roof, out in the cattle field, complete with a rain gutter and down spout pipe that directs the water into a 1000-liter concrete water tank. The small open house serves two purposes, to house the young men working in the cattle farm and to harvest rainwater for the animals. In addition, the family also built 4 concrete lined open style pits that resemble sand bunkers on a golf course but much smaller in size to collect and pond rain water(in the dry season, the pits are refilled with water from the concrete tank). These small concrete structures are strategically built and located around the different parts of the cattle field to ensure the animals wherever they graze on the 40-acre field have access to drinking water. High water demand in agriculture is one of the many problems encountered by small and large scale farmers in Samoa, an issue reiterated by the two rural farming households in the study.

Supplementing water demands for small family business was the main purpose behind RWH systems of two urban households (see Table 3). Car washing and laundry services are two water dependent operations that practice RWH to supplement water from the mains supply and to manage operation costs such as the monthly water bill. It was also observed during the rural focus group session conducted at one of the beach fales in Aleipata, that RWH was a significant feature of the operation with two 10,000 liters' polyethylene rainwater tanks that provide water for the bathrooms and showers.

**RWH and social desirability**

Household RWH is socially sustainable because all members of the household(and neighbors) irrespective of age, gender, and social status collectively benefit. Every household member has an established real need for reliable clean water. Daily household operations such as cooking, cleaning and washing are less burdensome knowing that there is a guaranteed supply of water in the event of an interruption to the mains supply, which occurs quite often, particularly in the rural parts of the island. Ownership and responsibility of managing water usage and looking after (tausialelei) of the rainwater tank is equally shared by both males and females in the household.

**Community RWH**

The idea for a village center RWH system based at the village primary school to take advantage of the larger roof surface area of the school building was raised in the rural focus group meeting as a practical means for collecting and storing water that is accessible to the wider village community. A similar water collection point using three 10,000 liter tanks was set up at the district hospital after the 2009 tsunami and the opportunity remains for a similar RWH system but using the village

primary school building. Having a community based RWH system centered at the village owned primary school allows access to all members of the village, particularly the economically vulnerable households, which goes a long way to achieving Sustainable Development Goal 6 of ensuring equitable access to safe drinking water for all by 2030.

**Other observed water related behaviors and comments**

In the course of the study, a set of behaviors and attitudes that do not necessarily fit in the thematic groupings stated above were observed. First, the respondents generally seem to display a certain degree of complacency towards the idea of water use and conservation. Presumably, the relative abundance of fresh water either from rainfall or piped water propagated a nonchalant, carefree attitude that potentially hinders government efforts towards water resources management, particularly with the view towards climate change impacts on fresh water resources in the small island states of the Pacific.

Fifty percent (5/10) of the urban households with reticulated water supply only, were observed with some very poor attitudes towards the use and management of their water supply. For instance, two households with small outdoor taps apparently used for watering the garden were leaking water, another had young children playing with the hose over the entire duration (1 hour) that the questionnaire was being administered. Others merely had the taps running while hand washing items of clothing.

The fresh water spring/pool in one of the study villages (Vailoa), provides an alternative source of fresh water that is mostly used for bathing and drinking by families without reticulated water supply. Given that more than 80 percent of households in Vailoa village have access to reticulated water supply [and RWH systems], lessens the demand on the village fresh water pool which was severely damaged in the 2009 tsunami, but has since been restored through government assistance to villages affected by the 2009 tsunami. The fresh water pool continues to provide the backstop for the village of Vailoa Aleipata in the dry season, when the mains supply is either rationed or turned off for days depending on the state of the reservoir. Usage of the village fresh water pool is very pronounced among households without RWH systems.

Owning a RWH polyethylene tank empowers the household to improve their livelihoods and social status in the village. It is not unusual to associate water tanks among other household assets such as white goods products, vehicle, livestock, plantation, and a European styled dwelling as an indicator of the household's social – economic placing (tamaoaiga) in the village community. A similar perception cannot be deduced from the urban respondents.

## Conclusion

In this study, RWH is presented as a positive action that provides the means for households to manage and control their water demands. By the same token, RWH at the household level can save a sizable volume of relatively good quality water at an economical cost. Understanding the issues that influence the households' water decision-making will contribute to water security first and foremost for the household, village and the rest of the country. As demonstrated in the study, the household decision to invest in a RWH system is a response to several factors such as poor or unreliable mains supply, farming needs, and to support water dependent small family businesses.

RWH provides subsidiary benefits such as reduced vulnerability of households to water rationing in the dry season and interrupted reticulated supply during the wet season. Equally important, the practice of RWH increases the adaptive capacity of the households to water resource management. People learn to value a resource that is pivotal to their socioeconomic functioning. A resource that was once freely available, but now find that they have to pay for it.

Combining mains and RWH is an efficient way to balance water reliability, cost and security. The primary decision by households to invest in a RWH system was to combat unreliable water supply from the mains as well managing the household water bill. The urban households without RWH systems, acknowledged a certain degree of vulnerability to water insecurity particularly at times of restricted reticulated supply which is becoming a frequent occurrence during the wet season.

Numerous social, economic and environmental benefits of RWH were identified by the respondents drawing attention to and supporting further studies into other forms of RWH technologies available and practiced elsewhere in the world, to augment roof top RWH that is commonly practiced in Samoa.

Household owned and operated RWH systems is advocated in this study as a simple and cost saving action to enhance household resilience to extreme climate change events that can impact on the future availability of fresh water resources. This is important in the face of projected water scarcity associated with a rapidly urbanizing population and growing numbers of water dependent small businesses both formal and informal. When households and communities collectively cooperate to harvest rain water, the per capita investment in large scale reservoirs required by the main water service provider (Samoa Water Authority) is minimized.

Overall, to ensure maximum benefits of RWH, the government through the relevant ministries that deal with water resources management, water policy making, and water delivery, in conjunction with the Plumbing Association of Samoa should seriously consider making RWH mandatory. This can be addressed in an amendment to the existing building code regulations to incorporate provisions for RWH systems to be installed for all newly constructed residential dwellings.

## References

Bekkers,B., Berking,J and Schutt,B. 2013. " Ancient Water Harvesting Methods in the Drylands of the Mediterranean and Western Asia". *Journal for Ancient Studies.*2:145-164. http://journal.topoi.org/index.php/etopoi/article/viewFile/174/205 (accessed 4 November 2016)

Barron,J. 2009. *Rainwater Harvesting: A Lifeline for Human Wellbeing.* UNEP/Earthprint. Amazon.com.

Cain,Nicholas,L. 2014. 'A Different Path: The Global Water Crisis and Rainwater Harvesting'. *Consilience: The Journal of sustainable Developmen*t 12 (1):147-157.

Clark, J.W., Viessman, W,Jr., and Hammer, M,J. 1977. Water Supply and Pollution Control. New York: Harper and Row.

Duncan, D. 2011. *Fresh Water Under Threat . Pacific Islands- Vulnerability assessment of freshwater resources to environmental change.* United Nations Environment Programme. Bangkok.

FAO. 1993. *Irrigation Water Delivery Model.* Food and Agriculture Organization (Water Reports No. 7) Rome: Italy.

Global Water Partnership (GWP). 2017. *The need for an integrated approach.* https://www.gwp.org/en/About/why/the-need-for-an-integrated-approach/ (accessed 9 March 2017).

Julius,J.R., Prabhavathy,R.A and Ravikumar,G. 2013. "Rainwater Harvesting (RWH) - A Review". *International Journal of Scientific & Engineering Research*, 4(8):276-262.

Kallren,L. 1993. *Policy Issues – Case and Country Studies.* Proceedings of the Sixth International Rainwater Catchment Systems Conference. Nairobi: Kenya. http://eng.warwick.ac.uk/ircsa/abs/6th/abs6.pdf (accessed 31 October 2016).

Latham,B., and Schiller,E. 1984. *Rainwater Collection Systems: A Literature Review*. International Institute for Co-operation and Development, University of Ottawa, Ottawa, Canada.

Mallin, M.A;Johnson,V,L; and Ensign, S,H. 2008. 'Comparative impacts of stormwater runoff on water quality of an urban, a suburban, and a rural stream' Environ*Monit Assess* (2009)159:475-491. Doi:10.1007/s10661-008-0644-4.

Ministry of Natural Resources and Environment. 2012. *Water for Life: Water & Sanitation Sector Plan 2012-2016.* Apia.

Ministry of Natural Resources and Environment. 2008. *Water for Life: Water Sector Plan and Framework for Action (2008/9-2011/12).* Apia.

Petersen,E.K., and Pedersen,M.L. 2010. *The sustainable livelihoods approach. Approaches to Development.* Institute of Biology , University of Aarhus. http://ps.au.dk/fileadmin/Statskundskab/Dokumenter/subsites/Uland/TheSustainableLivelyhoodsApproach_Psych.pdf (accessed 9 November 2016).

Samoa Bureau of Statistics. 2012. *Population and Housing Census 2011 Analytical Report.* Census Surveys division.

Samoa Bureau of Statistics. 2017. *Population Snapshot and Household Highlights.* 2016 Census Brief No. 1.

South Pacific Applied Geoscience Commission (SOPAC). 2004. *Harvesting the Heavens. Guidelines for Rainwater Harvesting in Pacific Island Countries.* (SOPAC Joint contribution Report). Suva: Fiji. http://ict.sopac.org/VirLib/JC0178.pdf (accessed 31 October 2016).

South Pacific Applied Geoscience Commission (SOPAC). 2009.*Energy Footprints for Water Supplies in Pacific Islands.* PECC Seminar Auckland 8-11 December 2009. https://www.pecc.org/resources/infrastructure-1/1415-energy-footprint-for-water-supplies-in-pacific-islands-1/file (accessed 2 November 2016).

Srinivasan,V.,Lambin,E.F.,Gorelick,S.M.,Thompsen,B.H.,&Rozelle,S. 2012. 'The nature and causes of the global water crisis: Syndromes from a meta-analysis of coupled human-water studies.' *Water Resources.Res*.,48 W10516: 1-16. doi:10.1029/2011WRO11087

Taua'a, S. 2014. 'Water attitudes, consumption and waste at the household level' The *Samoa Water and Sanitation Journal.* Volume 1, No.1:1-31.

UNEP(United Nations Environment Programme). 2009. *Rainwater Harvesting : A Lifeline for Human Wellbeing*.http://www.unwater.org/downloads/Rainwater_Harvesting_090310b.pdf (accessed 18 December 2016).

Van der Bruggen, B., Borghgraef, K. &Vinckier, C. 2010. "Causes of water supply problems in urbanized regions in developing countries." *Water Resources Management*24(9): 1885-1902. doi:10.1007/s11269-009-9529-8.