

# Decentralized Water Management: Rainwater Harvesting, Greywater Reuse and Green Roofs within the GST4Water Project <sup>†</sup>

Sara Simona Cipolla <sup>1</sup>, Margherita Altobelli <sup>1</sup> and Marco Maglionico <sup>2,\*</sup>

<sup>1</sup> Interdepartmental Centre for Industrial Research in Building and Construction, University of Bologna, 40133 Bologna, Italy; sara.cipolla@unibo.it (S.S.C.); margherita.altobelli3@unibo.it (M.A.)

<sup>2</sup> Department of Civil, Chemical, Environmental and Materials Engineering, University of Bologna, 40136 Bologna, Italy

\* Correspondence: marco.maglionico@unibo.it; Tel.: +39-51-209-3369

<sup>†</sup> Presented at the 3rd EWaS International Conference on “Insights on the Water-Energy-Food Nexus”, Lefkada Island, Greece, 27–30 June 2018.

Published: 30 July 2018

**Abstract:** this study proposes the results of a research activity devoted to the analysis and development of methodologies, models and strategies, which allow integrating decentralized solutions such as rainwater harvesting, greywater reuse systems, and green technologies in buildings. A methodology based on a hydraulic/hydrological model developed by means of SWMM is presented. It allows estimating the optimal size of the storage tanks, considering the overall efficiency of the system, and calculating the wastewater overflows reduction. This study is carried out within the Work Package three (WP3) of the GST4Water project funded by the Emilia-Romagna Regional Council (Italy) through the European Regional Development Fund 2014–2020 ERDF—ROP.

**Keywords:** rainwater harvesting; green roof; greywater; SWMM

---

## 1. Introduction

Clean and safe drinking water is scarce. Undoubtedly, the situation will get even worse in the near future because global population is growing by 1.10 per cent per year, yielding an additional 83 million people annually [1]. It is also well known that the relationship between the demand for water and population growth is not linear; in fact, the first one has doubled the second because of changing in water consumption patterns [2]. Moreover, climate change and the following raising in air temperatures will cause an increase in the frequency of drought and flooding periods in many countries. Water scarcity, which already affects more than 40% of the global population, is projected to rise consequently [3]. Despite municipal water withdrawal accounts only for roughly 10 percent of the total water consumption globally [2], the implementation of technological solutions to reduce water withdrawal at the urban scale is strongly suggest worldwide and it represents one of the targets of the goal 6 of the 2030 Agenda for Sustainable Development. The above-mentioned has taken into consideration during the draft of the project named “Green-Smart Technologies for Water (GST4Water)”. The Emilia-Romagna Regional Council (Italy), through the European Regional Development Fund 2014–2020 ERDF-ROP, financed the project.

GST4Water project is made of four work-packages (WPs); the first two pertain to the development of: (a) a real time monitoring system of the water consumptions at household; (b) a software cloud platform to manage and process information from the monitoring system; (c) a user-friendly software interface to transfer information to users and water companies. WP1 analyses the

information from outdoor flow meters [4], while WP2 analyses the indoor devices (showers, toilet flushing, washing machine, etc.).

The third work package (WP3) is aimed at developing models and strategies for optimal reuse of the grey and rainfall water within buildings, while WP4 provide the evaluation of the sustainability of the previously proposed actions with the urban metabolism model and a Life Cycle Analysis (LCA) [5]. This study, developed within WP3, fits this framework with a research activity devoted to the analysis and development of methodologies, models and strategies which allow integrating decentralized solutions such as rainwater harvesting, grey water reuse and green technologies in Emilia Romagna Region (Italy). Cisterns to store rainwater have been generally used since 3<sup>rd</sup> millennium BC in the entire regions around Mediterranean and Near East [6]. Ever since, rainwater-harvesting systems have evolved, and nowadays represent a valid technology to increase the sustainability of a building [7]. A typical domestic RainWater Harvesting System (RWS) comprises four basic elements: a collection catchment area (roofs, impervious pavement surfaces, green roofs, etc.), a convey systems, a storage tank, and a pump system [8]. Generally, as illustrated in Figure 1, the rooftop is the rainfall catchment area; water after being collected by the conveyance system, is stored into a tank and finally pumped into the building or elsewhere (gardens, green roofs, etc.). Before being stored, rainwater goes to the treatment, which generally includes a first flush device and some filters. Any excess of water, respect to the storage capacity of the tank, is delivered into the sewer system with a tank overflow. When the water level inside the tank is lower than the safety threshold, it must be top-up with a finite volume of water coming from the mains water supply. To date, rainwater-harvesting research has been undertaken in many countries. Silva et al. [9] provide a useful review of studies focusing on both specific and general rainwater harvesting evaluations worldwide. In Italy, this topic has received more attentions in recent years, perhaps due to increasing periods of water shortage and urban floods. Italian studies can be categorized into three groups: (1) studies on sizing criteria to design RWSs under different climatic conditions [10–14]); (2) studies on the ability of DRWHS to act as source control technology to reduce stormwater runoff volume [15,16]; and (3) studies on the potential use of rooftop rainwater harvesting for food production [17]. In modern eco-friendly and sustainable buildings, RWSs are frequently combined with greywater reuse systems. This is a way to increase the productivity of decentralized water supplies. A Greywater Reuse System (GWS) is a plant in which the gently used water from bathtubs, showers, handwashing basins and washing machines, is purified, stored in a tank and reused for non-potable purposes. The volume of greywater produced by any household depends on the number, age, lifestyle and water usage patterns of the occupants. In terms of daily production, the literature indicates that the greywater volumes are in the range 43.6–117 L/p/d, with the maximum value recorded in the USA. [18] and the minimum in Ghana [19]. Moreover, the amounts of water consumed, and thus of greywater produced, may vary considerably depending on the presence or not of low consumption devices. In Germany, the standard water consumption is about 117 L/p/d, which drops to 100 L/p/d in new or recently retrofitted buildings. Relative graywater production, is 82 and 70 L/p/d respectively [20]. Similar values were found in Italy, during the monitoring activities carried out within the AQUASAVE project (LIFE 97 ENV/IT/000106). The average water consumption of potable water for households, equipped with low consumption devices, is about 106.4 L/p/d, of which 23% is used for toilet flushing; 33% for personal washing, 12% for dishwashers and washing machines, 4% for food preparation, and 28% for other uses [21]. RWSs and GWSs are alternative facilities that can be installed independently or in parallel. Last configuration is frequently called Hybrid Rainwater-GreyWater System (HRGWS) [22]. It helps offset the seasonal nature of rainfall, as greywater is generated regardless of climate conditions. Despite many local authorities promote the use of these technologies through tax deductions or incentives, the designing criteria are still not clear. In the Italian context, two methods are recommended by the Italian standard for RWSs [23], which are based on methods proposed by the German DIN 1989-1:2001-10 standard. There are not standard for GWSs neither for HRGWSs. In order to reduce this knowledge gap, this paper presents a model that designers and local authorities can use for the tank design or to evaluate the long-term

performances. Furthermore, the model is able to provide some information about the stormwater and wastewater reduction attributable to the presence of each technology installed.

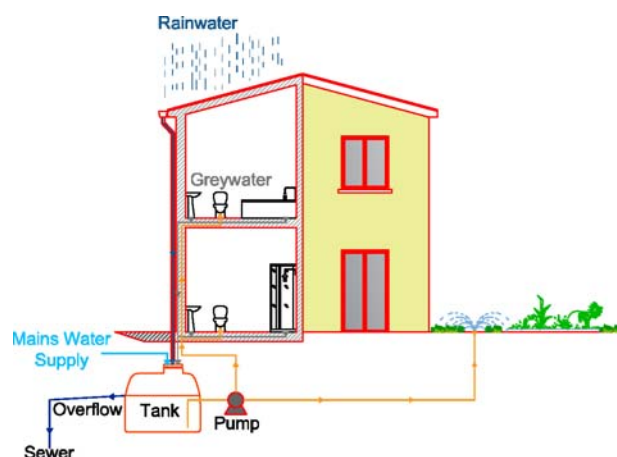


Figure 1. Schematic representation of a rainwater and greywater tank system.

## 2. Materials and Methods

### 2.1. The Model

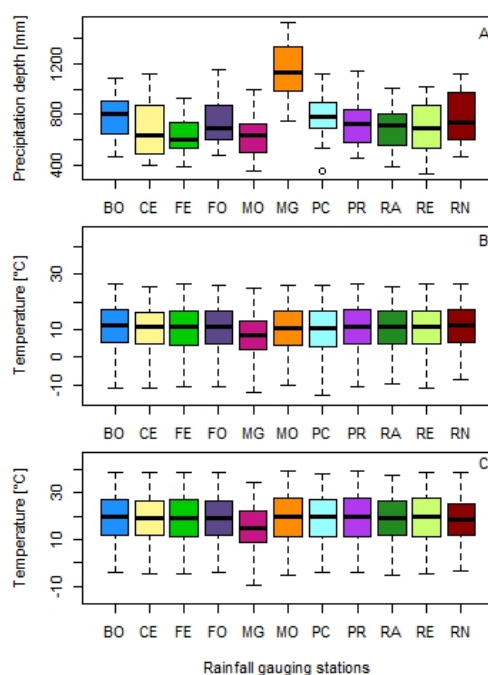
The hydraulic/hydrological model has been undertaken by means of EPA SWMM software, version 5.1.012 [24], as done by other authors (see Palla et al. [16] for an overview). A subcatchment, a pipe, two pumps, a weir, a node, two storage units, and two outfalls compose the model, which ensures the representation and simulation of a HRWHS system. Greywater has been modelled as a positive constant daily inflow to the tank, while the non-potable water demand to meet toilet flushing and garden irrigation supply has been modelled as a negative inflow to the tank and a pump system respectively. Water can continue to enter the tank, raising the water level until it reached the overflow pipe, at which point the water will be discharged into the sewer system through the overflow schematized by a weir. The water level within the tank is controlled by a SWMM rule, which is set to allow water to enter from the main water supply when the water level drops below the minimal required level. The outputs from this model are the predicted yield and the overflow over the simulation period as a function of the system setup (roof characteristics, rainwater demand, and tank storage volume). Continuous simulation are performed over 12-years at 1-day time interval; as for the initial condition the tank is assumed empty as generally recommended [16].

This model uses the “subcatchment” element to model the roof (rainfall catchments area). A subcatchment is a hydrologic unit whose parameters influence the runoff and thus the storage tank inflow [24]. Subcatchment has modelled as impervious catchments in which the total surface area is the footprint of the roof. Its main parameters (depression depth, N Manning, and % Zero-Imperv) have assigned in agreement with those proposed by Cipolla et al. [25]. A predesigned Low Impact Development (LID) module can be used to model green technologies such as green roofs, pervious pavements, biofilters etc. [24,26]. Green roofs are multi-layered systems that provide an opportunity to manage stormwater runoff directly at the source [27,28], in fact they are known to retain rainwater and delay runoff [29]. In this study, the green roof has been modelled as a bio-retention cell composed by three layers representing the vegetation, the substrate (10 cm depth) and the drainage material respectively. Modelling parameters have been taken from a previous study [25].

Rainfall distribution depends on many factors such as altitude, wind direction, sea proximity etc. For this reasons, the model illustrated in the previous section is applied to different localities. The chosen sites covers the main cities of the Region (10), and a further locality, selected because is close to the place with the highest annual precipitation depth recorded (1); this results in 11 localities that cover the whole region. Climate data (rainfall and air temperature) were sourced from the historical climate records provided by the Regional Agency for Prevention, Environment and Energy

(www.arpae.it). For each station 27 years of daily rainfall depth data (collected with a rain gauge sensibility of 0.2 mm), and 12 years of daily data of air temperature (2004–2016) were collected.

Figure 2 shows the box plots of the total annual precipitation depth (A), maximum (B) and minimum (C) daily air temperature. The bottom and the top of each box are the first and third quartiles, the length of the rectangle from top to bottom is the interquartile range (IQR), and the band inside the box is the second quartile (the median). The extreme lines shows the highest and lowest value excluding outliers. Figure 2 shows that the annual precipitation ranges between 338 mm (Reggio Emilia (2006)) and 1517.4 mm (Monghidoro (2014)). On an annual time scale, precipitation shows a high seasonal variability as well as air temperature. Rainfall are mostly concentrated in the late autumn-early winter, while the driest months are July and August. Simulations were performed over 12-years (2005–2016) at 1-day time interval. As said previously, household greywater is generated regardless of climate conditions. However, its daily volume is affected by several factors such as the quality of water supply, the activities in the household, and the age and lifestyle of inhabitants [30]. Based on the ACQUASAVE study [21], the daily volume of greywater generated by each household occupant has been considered a constant value equal to the 33% of the overall daily water consumption which corresponds to water from showers, bathtubs and handwashing basins. Estimating accurately the non-potable water demand from the tank is as important as having access to appropriate input data. The indoor water demand (toilet flushing) has settled as a single value for all time-steps. This assumption has considered adequate by other studies [14]. Regarding outdoor non-potable water demand (i.e., garden irrigation), it usually exhibit a seasonal variation that needs to be parameterized. Irrigation timing and volumes were determined based on rules dependent on the month of the year and the size of the garden.



**Figure 2.** A Boxplots of the historical: (A) rainfall recorded over 27 years (1990–2016); (B) Minimum daily air temperature, and (C) maximum daily air temperature over 12 years (2005–2016) for the 11 cities in Emilia Romagna Region (Italy).

Three indexes, evaluated with respect of the entire simulation period, provide the performances of different system configurations. The first is the water-saving efficiency,  $E$ , in which the rain/grey water supply  $Y_t$  ( $m^3$ ) is compared with the non-potable water demand  $D_t$  ( $m^3$ ) both in each time step  $t$ , and  $T$  is the total number of time steps in the period of simulation [11].

$$E = \frac{\sum_{t=1}^T Y_t}{\sum_{t=1}^T D_t} \tag{1}$$

The second index is the wastewater overflow ratio,  $WO$ , in which the non-potable water (greywater and rainwater) exceeding the tank capacity  $WO_t$  [ $m^3$ ] is compared with the total system inflow  $W_t$  ( $m^3$ ) both in each time step  $t$ , and  $T$  is the total number of time steps in the period of simulation.

$$WO = \frac{\sum_{t=1}^T WO_t}{\sum_{t=1}^T W_t} \tag{2}$$

The last index is the rainwater retention,  $R$ , in which the precipitation volume  $P_t$  ( $m^3$ ) less the subcatchment runoff  $R_t$  ( $m^3$ ) is compared with  $P_t$ , both in each time step  $t$ , and  $T$  is the total number of time steps in the period of simulation [25].

$$R = \frac{\sum_{t=1}^T P_t - R_t}{\sum_{t=1}^T P_t} \tag{3}$$

### 2.2. Case Study

Six different scenarios were simulated using the real 12 years rainfall and temperature series. Scenarios differs for system configuration and building’s properties (Table 1). All buildings are considered located in the city of Bologna (Italy) and inhabited by three people. A total water consumption of 106, 4 L/p/d (low consumption devices), of which the 23% (24.12 L/p/d) are used for toilet flushing, has been assumed. The greywater production has been set equal to 33% (35.12 L/p/d) of the total water consumption [21]. Buildings type A have no garden, while the type B has 150  $m^2$  of garden, which is irrigated from April 1 to the end of September of each year, with a constant daily volume of 3 L/ $m^2$ . All buildings are equipped with an impermeable flat roof (150  $m^2$ ), however in A3 and B3 the traditional roof is covered by an extensive green roof (10 cm substrate) whose properties are fully described in Cipolla et al. [27]. Buildings also differ for the type of decentralized plant installed, the house A1 and B1 are equipped with a system for harvesting and recovering only the rainwater (RWS), while the others are equipped with a tank that holds both gray and rain waters (HWS). Each scenario has been simulated from 1 January 2005 to 31 December 2016 (4383 days) under 3 tank volumes (2, 6 and 12  $m^3$ ).

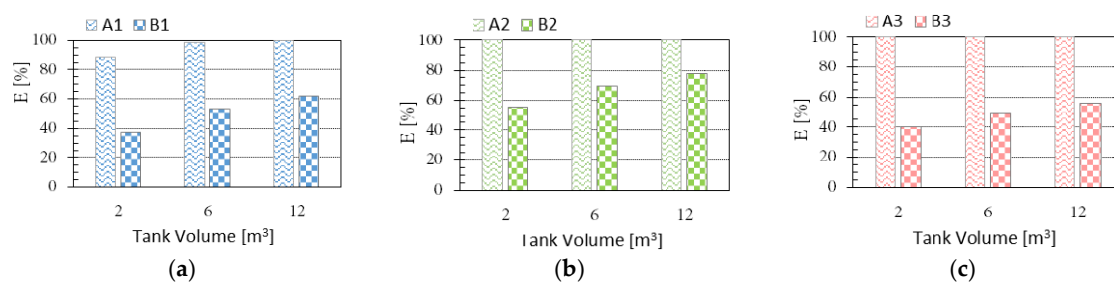
**Table 1.** Building’s code, decentralized system type, number of inhabitants, roof area, type of cover roof, garden area and irrigation volume.

Building’s Code	System Type	Inhabitants (-)	Roof Area ( $m^2$ )	Roof Type	Garden Area ( $m^2$ )	Irrigation Volume (L/ $m^2$ /d)
A1	RWS	3	150	Impervious	-	-
A2	HWS	3	150	Impervious	-	-
A3	HWS	3	150	Green roof	-	-
B1	RWS	3	150	Impervious	150	3
B2	HWS	3	150	Impervious	150	3
B3	HWS	3	150	Green roof	150	3

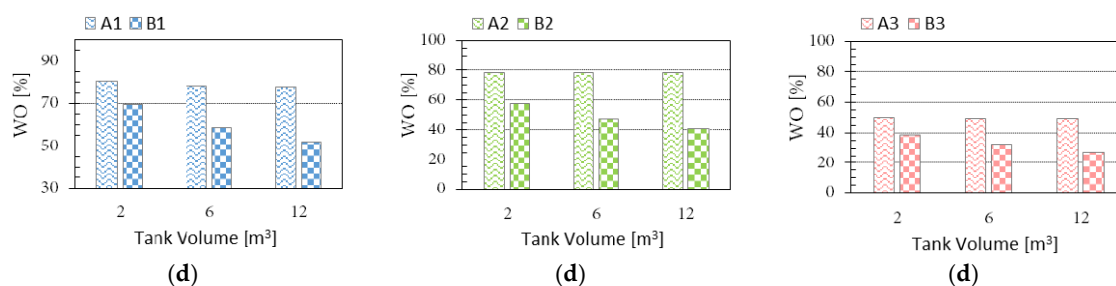
### 3. Results and Discussion

Simulations of the hydrological and tank daily water balance were carried out for each of the six scenarios to evaluate the performance of the decentralized systems in reducing non-potable water demand and wastewater discharge. The performances of each system configuration are assessed at the entire simulation period (12 years long). For each scenario will be presented the change in water saving efficiency (E) and wastewater overflow (WO) while varying the tank size. The water saving efficiency indicates the percentage of non-potable water demand that can be fulfilled by the tank, and therefore should not be bought from water public utility at a price. The other index, WO, indicates the percentage of wastewater (greywater + rainwater) that is directly conveyed to the drainage network that is directly conveyed to the drainage network, the lower this percentage the greater the environmental impact of the solution proposed. Finally, R, which can be calculate only in the last two scenarios, provide the ability of green roof in retain rainwater.

Figure 3a,b show the water saving efficiency and the wastewater overflow varying with tank size for scenario A1 and B1. Both buildings are equipped with rainwater harvesting systems and differs only for the presence of 150 m<sup>2</sup>-irrigated garden. From these histograms (Figure 3a), it is possible to observe that the greater the tank volume the higher the water saving efficiency. Scenario A1 is able to achieve 88.8% water saving efficiency only with 2 m<sup>3</sup> tank volume, while 6 and 12 m<sup>3</sup> volumes bring to almost 100% efficiency. Therefore, in terms of construction technology, they determine an adding complexity, which means a more expensive plant. Scenario B1 shows a different behavior; in fact, the water requirement for irrigation in summer periods, which in Italy is the drier season, determines a strong decrease in water saving efficiency that drops to 37.6% with 2 m<sup>3</sup> tank, rising up to 61.9% with 12 m<sup>3</sup> tank volume. Simulation results confirm the mitigating impact of the system on wastewater runoff volume generation. Scenario A1 determines a WO ranging in the range 80.6–78.2 considering both rainwater and greywater together, and 74.2–71.0% considering only rainwater (Figure 3d). This means that despite a relevant increase in tank volume the environmental benefit acquirable is modest. Scenario B1 shows better results, in fact varying from 2 to 12 the volume of the tank WO decrease of a roughly 17.5%. Considering only the reduction of rainwater runoff volumes, this percentage grow up to 23.3%. Scenario A2 and B2 depicts the same building configuration of A1 and B1 respectively. However, they show a favorable performance both in terms of water saving efficiency (Figure 3b) either in wastewater overflow reduction (Figure 3e). This is certainly attributable to the greywater reuse, which represent a constant daily inflow generated regardless of climate conditions. As a consequence water saving efficiency rise up to 100% even with 2 m<sup>2</sup> tank for scenario A1, and improved of a calculated roughly 16% regardless of tank size for scenario B2. The WO index instead shows a different behavior. The A2 scenario is characterized by a daily demand for non-drinking water, which is lower than daily greywater production; consequently, the system is not able to lead to significant reductions in the volumes spilled into the sewer system. B2 behavior is different, the possibility of using gray water for summer irrigation determines a significant reduction of both potable water consumption and wastewater overflows. Scenario A3 and B3 depicts the same system configuration of A2 and B2 respectively. However, in these buildings an extensive green roof covers the roof surface, which represent the catchment basin of the rainwater harvesting system. This technology, frequently called “rainwater source control technology”, is able to retain stormwater in its layers and thus reduces the amount of water harvestable [27]. Scenario A1 seems not be affected by the presence of the green roof as demonstrated by a water saving efficiency of 100% regardless of tank volume (Figure 3c). On the contrary, scenario B3 is affected by the presence of the green roof that reduces the stormwater runoff, especially during the summer, and the volume of recoverable rainwater consequently. In addition the green roof increases the average dry time between two rain events. All the above determines a reduction in efficiency which drops down in the range 40.4–55.9%. However, this decrease in efficiency is offset by a significant improvement in in terms of wastewater overflow reduction. In fact, the WO index ranges from 49.73–49.19% and 38.65–27.19 in the A3 and B3 scenario respectively (Figure 3f). Both scenarios allow to calculate the last index which is called Retention (R) and, to date, it is the most cited hydrological performance metric of a green roof [25]. Usually retention can range from 11% to 76.4% with an average retention value of 46.1%, as showed by Cipolla et al. [25]. The retention value measured in the green roof present in scenarios A3 and B3, equal to 44.5%, falls perfectly within this range.







**Figure 3.** Water saving efficiency (top) and wastewater overflow (bottom) with respect to three-tank volume (2, 6 and 12 m<sup>3</sup>) for scenario A1 and B1 (a, d), A2 and B2 (b, e), A3 and B3 (c, f) respectively.

#### 4. Conclusions

The results of this paper show clearly that system configuration and non-potable water demand can significantly vary the water saving efficiency. Despite a good ability of RWS in reducing drinking water consumption in building without garden (A1) even with the smallest tank volume (2 m<sup>3</sup>), simulation results show that the presence of a greywater inflow determine a substantial increase in water saving efficiency. In the coming months the model will be equipped with a graphical interface that will allow users to use it in a simple and intuitive way to test different plant combinations according to the characteristics of the buildings. The resulting software can be used by the designers to identify the plant combination and the optimal tank volume and by the planning authorities to evaluate the proposed design solutions in an objective way.

**Acknowledgments:** This study is financed by the European Regional Development Fund 2014–2020 ERDF-ROP through the “Green and Smart Green-Smart Technologies for a sustainable use of the Water resource at urban and building level” (GST4Water) Project.

#### References

1. United Nations, Department of Economic and Social Affairs. *Population Division World Population Prospects: The 2017 Revision, Key Findings and Advance Tables*; Working Paper No. ESA/P/WP/248; UN: New York City, NY, USA, 2017; doi:10.1017/CBO9781107415324.004.
2. United Nations World Water Assessment Program (WWAP). *The United Nations World Water Development Report 2015: Water for a Sustainable World*; UNESCO: Paris, France, 2015.
3. United Nations World Water Assessment Program (WWAP). *The United Nations World Water Development Report 2016: Water and Jobs*; UNESCO: Paris, France, 2016.
4. Luciani, C.; Casellato, F.; Alvisi, S.; Franchini, M. From water consumptions smart metering to leakage characterization at district and user level: The GST4Water project. In Proceedings of the 3rd EWaS International Conference ‘Insights Water-Energy-Food Nexus’, Lefkada Island, Greece, 27–30 June 2018.
5. Di Fusco, E.; Lenci, A.; Liserra, T.; Ciriello, V.; Di Federico, V. Sustainability assessment of urban water use from building to urban scale in the GST4Water project. In Proceedings of the 3rd EWaS International Conference ‘Insights Water-Energy-Food Nexus’, Lefkada Island, Greece, 27–30 June 2018.
6. Mays, L.W. Use of cisterns during antiquity in the Mediterranean region for water resources sustainability. *Water Sci. Technol. Water Supply* **2014**, *14*, 38–47, doi:10.2166/ws.2013.171.
7. Angrill, S.; Segura-Castillo, L.; Petit-Boix, A.; Rieradevall, J.; Gabarrell, X.; Josa, A. Environmental performance of rainwater harvesting strategies in Mediterranean buildings. *Int. J. Life Cycle Assess.* **2016**, *22*, 398–409, doi:10.1007/s11367-016-1174-x.
8. Campisano, A.; Butler, D.; Ward, S.; Burns, M.J.; Friedler, E.; DeBusk, K.; Ghisi, E.; Rahman, A.; Furumai, H.; Han, M. Urban rainwater harvesting systems: Research, implementation and future perspectives. *Water Res.* **2017**, *115*, 195–209, doi:10.1016/j.watres.2017.02.056.
9. Silva, C.M.; Sousa, V.; Carvalho, N.V. Evaluation of rainwater harvesting in Portugal: Application to single-family residences. *Resour. Conserv. Recycl.* **2015**, *94*, 21–34, doi:10.1016/j.resconrec.2014.11.004.
10. Campisano, A.; Lupia, F. A dimensionless approach for the urban-scale evaluation of domestic rainwater harvesting systems for toilet flushing and garden irrigation. *Urban Water J.* **2017**, *14*, 883–891.

11. Campisano, A.; Gnecco, I.; Modica, C.; Palla, A. Designing domestic rainwater harvesting systems under different climatic regimes in Italy. *Water Sci. Technol.* **2013**, *67*, 2511–2518, doi:10.2166/wst.2013.143.
12. Campisano, A.; Modica, C. Optimal sizing of storage tanks for domestic rainwater harvesting in Sicily. *Resour. Conserv. Recycl.* **2012**, *63*, 9–16, doi:10.1016/j.resconrec.2012.03.007.
13. Liuzzo, L.; Notaro, V.; Freni, G. A Reliability Analysis of a Rainfall Harvesting System in Southern Italy. *Water* **2016**, *8*, 18, doi:10.3390/w8010018.
14. Palla, A.; Gnecco, I.; Lanza, L.G. Non-dimensional design parameters and performance assessment of rainwater harvesting systems. *J. Hydrol.* **2011**, *401*, 65–76, doi:10.1016/j.jhydrol.2011.02.009.
15. Campisano, A.; Modica, C. Rain water harvesting as source control option to reduce roof runoff peaks to downstream drainage systems. *J. Hydroinform.* **2015**, *18*, 23–32, doi:10.2166/hydro.2015.133.
16. Palla, A.; Gnecco, I.; La Barbera, P. The impact of domestic rainwater harvesting systems in storm water runoff mitigation at the urban block scale. *J. Environ. Manag.* **2017**, *191*, 297–305.
17. Lupia, F.; Baiocchi, V.; Lelo, K.; Pulighe, G. Exploring Rooftop Rainwater Harvesting Potential for Food Production in Urban Areas. *Agriculture* **2017**, *7*, 46, doi:10.3390/agriculture7060046.
18. Yu, Z.L.T.; Rahardianto, A.; DeShazo, J.R.; Stenstrom, M.K.; Cohen, Y. Critical Review: Regulatory Incentives and Impediments for Onsite Graywater Reuse in the United States. *Water Environ. Res.* **2013**, *85*, 650–662, doi:10.2175/106143013X13698672321580.
19. Dwumfour-Asare, B.; Adantey, P.; Nyarko, K.B.; Appiah-Effah, E. Greywater characterization and handling practices among urban households in Ghana: The case of three communities in Kumasi Metropolis. *Water Sci. Technol.* **2017**, *75*, 813–822, doi:10.2166/wst.2017.229.
20. Fachvereinigung Betriebs- und Regenwassernutzung e.V. (Association for Rainwater Harvesting and Water Utilization) (FBR). *Greywater Recycling, Planning Fundamentals and Operation Information*; BR-Information Sheet: Darmstadt, Germany, 2005.
21. Failla B, Spadoni M, Stante LD, Cimatti E, Bortone G. The Aquasave Project: An Innovative Water Saving System in a Residential Building, Italy. *Integr. Water Resour. Manag.* **2001**, 121–125. Available online: <https://ambiente.sostenibilita.enea.it/pubs/3913> (accessed on 29 July 2018).
22. Leong, J.Y.C.; Oh, K.S.; Poh, P.E.; Chong, M.N. Prospects of hybrid rainwater-greywater decentralised system for water recycling and reuse: A review. *J Clean. Prod.* **2017**, *142*, 3014–3027
23. UNI/TS 11445. *UNI/TS 11445: Impianti Per la Raccolta e Utilizzo Dell' Acqua Piovana Per Usi Diversi Dal Consumo Umano—Progettazione, Installazione e Manutenzione*; Ente Italiano di Normazione: Milano, Italy, 2012.
24. Rossman, L.A.; Huber, W.C. *Storm Water Management Model Reference Manual Volume, I.—Hydrology*; EPA: Washington, DC, USA, 2016.
25. Cipolla, S.S.; Maglionico, M.; Stojkov, I. A long-term hydrological modelling of an extensive green roof by means of SWMM. *Ecol. Eng.* **2016**, *95*, 876–887, doi:10.1016/j.ecoleng.2016.07.009.
26. Gambi, G.; Maglionico, M.; Tondelli, S. Water management in local development plans: The case of the old fruit and vegetable market in Bologna. *Procedia Eng.* **2011**, *21*, 1110–1117.
27. Cipolla, S.S.; Maglionico, M.; Stojkov, I. Experimental Infiltration Tests on Existing Permeable Pavement Surfaces. *Clean Soil Air Water* **2016**, *44*, 89–95, doi:10.1002/clen.201400550.
28. Casadio, A.; Cipolla, S.S.; Maglionico, M.; Martinini, P. Numerical modeling of the sewer system of Rimini (Italy) and strategies for the CSOs reduction on the Adriatic Sea. *Environ. Eng. Manag. J.* **2013**, *12*, 121–124.
29. Palla, A.; Gnecco, I.; Lanza, L.G. Hydrologic Restoration in the Urban Environment Using Green Roofs. *Water* **2010**, *2*, 140–154, doi:10.3390/w2020140.
30. Antonopoulou, G.; Kirkou, A.; Stasinakis, A.S. Quantitative and qualitative greywater characterization in Greek households and investigation of their treatment using physicochemical methods. *Sci. Total Environ.* **2013**, *454–455*, 426–432, doi:10.1016/j.scitotenv.2013.03.045.

