Comprehensive environmental assessment of rainwater harvesting systems: A literature review

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Supplementary Material

Table S1. Research studies about LCA of water use systems.

Reference	Main goal	Functional unit	Time of analysis	Main results
Amores et al. [166]	Environmentally analyse the urban water cycle stages (abstraction, treatment, pumping, distribution, sewage collection and wastewater treatment) in Tarragona, Spain.	1m³ of potable water supplied to consumers.	The entire water life cycle	The main environmental impacts were caused by 35.2% in potable water distribution, 20.5% in pumping and 13.8% in sewage treatment.
Lemos et al. [167]	Assess the life cycle of all system stages: abstraction and treatment, distribution, sewage collection, treatment and disposal of wastewater and water administration, in Aveiro, Portugal.	1 m³ of potable water at the point of consumption.	Reference year (2008)	The water abstraction and treatment stage was the most relevant for most impact categories because most electricity consumption occurred during these stages. The most significant contributors to the environmental impact were energy consumption and nutrient discharge into the sea.

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Chang et al. [172]	Assess energy consumption and associated greenhouse gas emissions in the operational phases of urban water reuse systems in South Korea.	1m³ of processed water supplied to end-users.	Calendar year	Decentralised wastewater reuse systems and rainwater harvesting systems used for non-potable purposes showed energy demands equal to or greater than the conventional process but lower greenhouse gas emissions.
Ghimire et al. [168]	Compare the rainwater harvesting system of a commercial building with the centralised public supply in Washington (USA).	1 m³ of rainwater and municipal water delivery system.	50 years (rainwater) and 100 years (municipal water)	The rainwater used performed better than the centralised system concerning the impacts analysed, except for ozone depletion.
Morales-Pinzón et al. [175]	Assess environmental and financial impacts of rainwater harvesting systems in different neighbourhood configurations in some cities in Spain.	Abstraction, storage and supply of 1 m³ of rainwater to be used as non-potable water for a washing machine.	50 years	The determining factor for the design of systems, both in environmental and economic assessment, was the scale of implementation. It was recommended to use a neighbourhood scale with reservoirs for collective use.
Angrill et al. [176]	Determine the strategy with the lowest environmental impact among different typologies of rainwater harvesting systems (tank location) in urban regions with different densities (compact and diffuse) in the Mediterranean region.	Abstraction, storage and supply of 1 m³ of rainwater per person per year to be used as non-potable water for a constant demand for laundry use.	50 years	The best scenario for compact and diffuse urban models was the tank located on the roof (impact reduction of up to 73% and 92% in the worst scenarios of the diffuse and compact models, respectively). Concerning population density, the environmental impact of implementing rainwater harvesting systems in compact densities is lower than in diffuse densities.

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Petit-Boix et al. [169]	Assess the impact of sustainable rainwater management practices, such as infiltration trenches, on preventing flood damage. Potential impacts avoided were related to cars and sidewalks that were not destroyed due to flooding.	Implementation of 179 infiltration trenches.	10 years	Regarding CO_2eq emissions, the environmental investment related to the infiltration trench was recovered when the destruction of a car or 84 m² of sidewalk was avoided, considered a short payback period due to the frequency of flooding events in the area.
Kalbush and Ghisi [179]	Compare the life cycle of ordinary and water-saving taps.	Taps.	4 years	Replacing ordinary taps with water-saving taps reduced water consumption by 26.2%, energy consumption by 13.6%, human toxicity by 4.6%, acidification by 0.2%, the potential of global warming by 14.8% and the depletion of the ozone layer by 15.8%.
Vaz et al. [168]	Analyse the energy life cycle and life cycle cost of rainwater harvesting systems using permeable pavements.	Pavement system.	10 years	In the current water consumption pattern, none of the systems evaluated was profitable or sustainable. However, compared to the non-permeable pavement, using rainwater collected from the permeable pavement was profitable.
Petit-Boix [169]	Evaluate the environmental performance of rainwater harvesting systems in the USA and European cities.	1 m³ of indoor water demand for toilet flushing and laundry services supplied with a combination of rainwater and potable water.	75 years	Compared to the business-as-usual scenario, the implementation of rainwater collection systems is beneficial from an environmental point of view, mainly due to the reduction in the runoff treatment needs.

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Gómez-Monsalve et al. [173]	Analyse and compare the environmental performance of a hybrid system, which integrates rainwater harvesting and greywater reuse, with a centralised system in a house in Bucaramanga, Colombia.	Collection, treatment, storage, and distribution of 1 m³ of water.	50 years	The hybrid system showed better environmental performance than the centralised system (lower environmental impacts in twelve of the thirteen midpoint impact categories and the three endpoint categories of the ReCiPe methodology). The operational phase caused more environmental impacts than the construction phase.
Marinoski and Ghisi [65]	Evaluate the environmental performance of hybrid rainwater and greywater systems in residential buildings in southern Brazil.	The total volume of water consumed in the house.	20 years	The hybrid rainwater and greywater system scenario was the most environmentally friendly option in single-family homes. The most significant environmental impacts in the life cycle assessment were related to the operational phase, mainly due to energy consumption.
Rashid et al. [177]	Assess the environmental impacts of rainwater harvesting systems made of different tank materials: high (HDPE) and low (LDPE) density polyethylene, ferrocement and steel, among other aspects.	Supply of non-potable water demand of 332 L/lot/day.	1 year	The HDPE tank had less impact in most impact categories than other tanks.
Yan et al. [174]	Evaluate the performance of a new point-of-use (POU) treatment device used to treat harvested rainwater to a potable standard compared to a centralised supply.	1 m³ of potable water delivered to end-users.	12 years	Potable water produced from the decentralised system (POU) performed worse compared to the centralised supply from an environmental point of view. It occurs to the large differences in the magnitude of throughput between a city-scale water treatment unit and a single POU treatment device.

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Leong et al. [170]	Assess the environmental and economic impacts of a centralised water system versus rainwater harvesting, greywater recycling and decentralised rainwater-grey water hybrid systems in a building.	1 m³ of non-potable water for toilet and irrigation.	50 years	The optimal systems were: the commercial hybrid system (highest water savings, less environmental impacts for seven categories and the second-fastest system to become economically viable) and the domestic rainwater harvesting system (second highest water savings, less environmental impacts than the centralised scenario in seven categories and the faster system to become economically viable).