An Application of Water Harvesting Façade Technology for Commercial Buildings/ The Case of Amman.

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Abstract

Jordan is considered one of the countries with the scarcest of water resources as the third most water scarce country in the world. Placed at only 20% of the water poverty level the research investigates the application of rain water harvesting technology on commercial buildings in Amman/Jordan and achieving a balance between what buildings consume and what they produce. Emphasizing procedural mechanism of implementation, and verification of the economic feasibility of system through studying the effectiveness in terms of cost, quantity of building consumption and harvested water. This research seeks to implement a system which utilizes façade cladding and roof collection by using curtain wall transoms to direct rainwater into vertical mullions. Then commercial buildings in the case of Amman can significantly benefit from rainwater harvesting technique. Research addresses the quantity of water consumed through calculations from water authority and comparing it with other similar building, then calculate harvested water through annual rainwater captured potential's formula. It concludes to understand the importance of system's implementation as new approach to be used in Amman with a good aesthetic appeal of greenery, and the efficiency of using it through feasibility study.

Keywords: **Water harvesting, water consumption, façade technologies, commercial buildings, green façade.**

1.Introduction:

Water efficiency is the smart use of water resources through water-technologies and some simple steps we can take around the building through design (partnership, 2017). Most buildings rely on municipal sources of potable water to meet their needs from appliances to landscape irrigation.

Although water-consuming activities often remain similar, the sophistication of water infrastructure as well as the quantities and use patterns can vary depending on the primary purpose of the building.

Efficiency is looking for new approaches that can reduce water consumption in the building and adopting those that prove to be visible. The improvements can be achieved through a combination of behavioral and technological fixes.

Water efficiency should be integrated early in the design and construction phase of buildings. The feasibility of certain efficiency measures can be enhanced by re-considering certain design features related to the water distribution network, water storage tanks, and other water supporting systems. Water distribution networks efficiency gains in commercial buildings through designing the internal network with clearly independent sectors, defined by the area of the building and the type of water consumption.

1.2. Water statistics and water account in Jordan:

The Jordan is considered one of the countries in the /world with the scarcest of water resources. It's placed at only 20% of the water poverty level Rainfall is confined largely to the winter season and ranges from around 660 mm in the north-west of the country to less than 130 mm in the extreme east.

Water sector in Jordan opposes many challenges like scarcity of renewable water resources, depletion of ground water, high losses during distribution and weakness in delivery, high population number and forced immigration, and per capita water supply is expected to be 90 m3/year in 2025 since buildings in Jordan use more than 200,000,000 m3 of water yearly, 555000 m3 per day.

The Annual water of rainfall in Amman 8300 m3, during the draught 11000 m3, and in wet years 11000 m3, while taking advantage of this quantity about 8% According to ministry of water and irrigation.

The continuous need for water resources to meet rising demands has had a great impact on the Jordanian environment, while ground water resource recharge amounts to approximately 4% of the total rainfall volume, whilst surface water amounts to 11% of total rainfall volume.

The ministry of water and irrigation (MWI) adopted water strategy and supplemented it with different water policies of groundwater management, irrigation water, water utilities, and wastewater management aiming to balance water demand and supply.

Regarding to the importance of water efficiency to achieve cost saving and cultivate corporate social responsibility practices due to limited potable water supply, while most buildings rely on them to meet their needs with the large amounts of wastewater.

Office buildings usually offer more than rooftops and glazed facade for rainwater harvesting. To maximize water collection, other impervious (hard) areas such as paved or tiled open spaces, where feasible, can be considered for rainwater harvesting. The amount of harvested rainwater is directly related to the size of the impervious area and the average annual precipitation.

Considering 80 percent rainwater collection efficiency, to account for losses due to evaporation, splash-out from gutters, and first flush diversion. The building envelope comprises all the building components that separate the inner side from the outer one building envelopes include the exterior walls, foundations, roof, windows and doors. The interaction of the sub-systems with the components of the building envelope, as well as certain activities of the occupan ts, can affect the performance of the building envelope.

1.3. Hypothesis:

Through the working on the commercial building in Amman (Appendix 1) as a case of water efficient building. It will be an evaluation mechanism for efficiency of harvesting technology and water building consumption. Then the research assumes that the implementation of hollow-mullions harvesting system on commercial building façade is more intensive and efficient than other buildings, as a ratio of water consumption and amount of harvested water regarding to its glazed façade. While it supposes the cost of implementation efficiency

1.4. Objectives:

1. The main objective of research is to seek the efficiency of an application of rainwater harvesting façade technology on commercial buildings in Amman to be self-sufficient design, depending on rainwater as a natural resource with low coast and easy implementation.
2. Designing of water efficient building considering how the building envelope accommodates systems as one loop of design from one technique to another.
3. Systems implementation with high quality and suitable cost. Well-designed systems and efficient techniques are implemented after feasibility study of design.

4. Making evaluation mechanism in case of using the techniques of efficiency on other buildings.
5. Satisfaction of users from using building technology from different aspects, cost, quality and aesthetic value.

The concept that using of technology in architectural design envelopes to get water efficient system in our buildings. And how much satisfied people are.

2. Methodology:

The research is a quantitative research based on calculations of:

- Amount of harvested water as quantity
- Benefits of harvesting / cost saving
- Cost of implementation or construction
- Payback period

3. Case Study:

Commercial buildings are limited to from 17m to unlimited height according to building code for Amman City, according to the Greater Amman Municipality regulations. The buildings are covered with glass that also commonly used, Aluminum, steel, stones, or other materials.

In this research the case study is in Amman in AlSSakhra street in east Amman (Plans and elevations are showed in appendix 1), this building is 1550 square meters office building under construction (finish in the middle of 2019), has 60 employees who work 8 hour shifts for 300 days a year, and receives 80 visitors per day. The building gets all its water supply, which is 1450 cubic meters a year, from the water utility.

4.Calculating water consumption of building

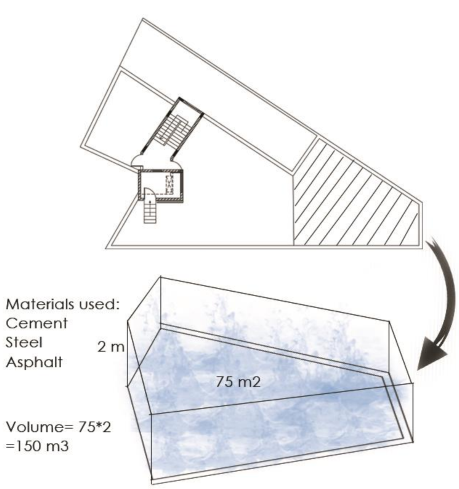
1. Current Water Use

Based on the water audit, this office building has 34 faucets, and 17 toilets. The average flow rates are around 4 liters/min for the faucets and 4.5 liters /flush for the toilets. The water use profile illustrated in this section indicates that the water uses for faucets and toilets represent around 84.4% of the total building's water consumption. These fixtures annual use is around 1200 cubic meters per year with 400 cubic meters for faucets, and 820 cubic meters for toilets.

2. Implementation of building water harvesting technology:

"Water harvesting techniques gather water from an area termed the catchment area and channel it to the cropping area or wherever it is required." (HDRA, 1991).

Rainwater harvesting is a technology used for collecting and storing rainwater from rooftops, the land surface or rock catchments using simple techniques such as jars and pots as well as more complex techniques such as underground check dams. The techniques usually found in Asia and Africa arise from practices employed by ancient civilizations within these regions and still serve as a major source of drinking water supply in rural areas.



Commonly used systems are constructed of three principal components; namely, the catchment area, the collection device, and the conveyance system. (Pacey, and Cullis, 1989).

Water system efficiency:

Where impervious area of building 200 m2 and annual rainfall 8300 then harvested water may reach 20% or 1300 m3 from roof. And 300 m3 facade harvested water.

- System description:

Rainwater harvesting system which utilities facade cladding with roof collection. Using the structural transoms or horizontal glazing members to direct rainwater falling on the panels into vertical mullions with a loop down to the basement collection system. Greenery on glazing system to make water filtration before consumption.

The expected benefits include saving 1330 cubic meters of water per year. (Calculations of harvested water). This would result in approximately 2940 JD (4175 $) reduction in the water and wastewater bill. (Calculations of quantity to the cost per cubic meter in Jordan).

Figure 1. Basement water tank detailing.

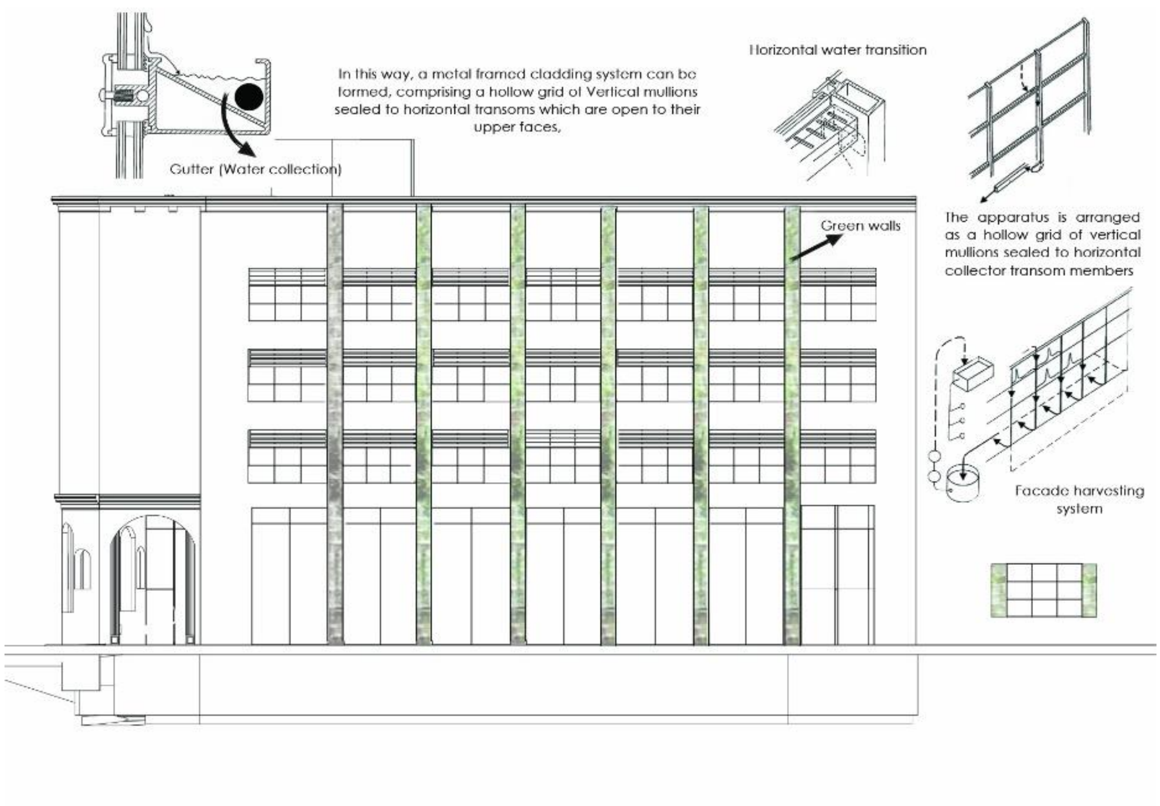
2.1 Implementation Cost:

Tank Cost:

Material	Quantity	Unit Cost	Cost
Cement	3 m^3	54 JD/ton	162
Steel	4 tons	480 JD/ton	1920
Asphalt	155 m^2	3 JD/m	465

The total cost of tank construction is around 2550 JD (3621 $)

Figure 2 . Hollow mullions water harvesting technology implementation



Feasibility study:

1. System's cost:

- Building consumption is equal to 1450 m3 from 1600 m3 of harvested water then 150 m3 is the surplus from harvesting system.

- Tank properties: 1500 m3 or 125/month then 150m3 of harvested water requires collection storage. The tank will be underground with dimensions (75m2*2m),

volume of 150 m3. Where 1.30 JD/cubic meter of building consumption related to Water Company (miyahuna) then 1.30*1500=1950 JD/year, 162.5+7.8= 170.3 JD/month.

System Description:

- Mullions system cost**:** through visiting (Al-Asbah Aluminum factory) and interviewing sales engineer who acknowledged that the facade does not need to increase in cost, since the cost per meter range from 80 to 120 JD which is the same cost with or without system implementation.

Figure 3.Water channeling and filtration

- Insulation cost: 155 m2*5=775, and 2250 professionalism. Then total cost of insulation is 3000 JD

- Cost of pump: 200 JD of 220 meters pump

Total Cost: 200+3000+3575+3300+620 =10700 JD / whole system

2. System's income: 170.3 JD /month then 2050 JD/year is the cost of water that building consumes and harvested water will cover.

Figure 4. Aesthetic appeal after implementation

3. Aesthetic value:

System implementation affects aesthetic appeal of building through green strips which are channels that collect water from mullions curtain grid system. Making survey to study the difference of aesthetic value for system and comparing form of design before and after system implementation.

5. Results and discussions:

1. Feasibility 10700 JD is the cost of system and 2050 JD is the income per year, then building needs 5 years to retrieves cost of implementation.

2. The water consumption of building is great related to water statistics in Jordan and the scarcity of resources. As a result of the large consumption, it is necessary to work on systems to increase the building suppliers.

3. There is no exploitation of the rainwater in the buildings which may be able to provide the water needs. Therefore, the focus of work on rainwater after studying its proportion in different areas and lead to a solution to the problem of water in Jordan by imposing a system on buildings that are feasible to apply to them.

4. The payback period and benefit-cost ratio presented in the calculator show that the retrofit of faucets and toilets is a highly profitable water use efficiency measure. You only need 10 months to pay back the money.

5. Rainwater harvesting is a traditional system that can be applied to the buildings. The application of the system with modern technology on glass facades is an effective treatment because commercial buildings are characterized by large glass facades. More than 50% of the facade of the commercial complex is glass and this type of building makes the system feasible.

6. When dealing with the system on the facade slightly affects the shape of the building exterior and aesthetics, the presence of greenery on the facade is an aesthetic element positively affects the building.

7. The application of the system to the building is not expensive considering the usefulness of the project and considering the water situation and the scarcity of its sources in Jordan.

6. Conclusions:

1. Jordan is one of the countries that suffer from the problem of water poverty, and the introduction of systems that help preserve existing water resources or exploit them, or reduce the use of water, is the most important things that must be dealt with at the present time in which Jordan is facing a water problem.
2. Commercial buildings are more water-intensive than residential buildings as per capita water consumption in Jordanian code. The surface area of the building is relatively large compared to other buildings, so a system of such buildings can be worked out after consideration of the rainfall in the area and the area that can help in the principle of water collection.
3. Hollow mullions system is enough system in Jordan to be used in commercial buildings to save water resources from deterioration.

7. Recommendations:

1. The economic feasibility study of the system confirms the effectiveness of its application to the buildings in Jordan. When applied to any building, the feasibility study must be carried out prior to the implementation process and taking into consideration the long-term water efficiency of the building.
2. Exploitation of the largest area of the building facade to apply the system to be a glass interface to be effective in the collection of rain water by a large and cover the need of the building for water. The water surplus of the rainwater harvesting process is directed to dams and places where rainwater collects.

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Appendixes 1

Drawings of commercial building in Amman; Plans (Basement, Ground, and First).