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REDUCING WATER CONSUMPTION WITH SUSTAINABLE BUILDING DESIGN; A CASE STUDY

Xhensila THOMOLLARI[1], Ümit BAHADIR[1], Vedat TOĞAN[1], Onur B. TOKDEMIR[2]

[1]Department of Civil Engineering, Faculty of Engineering, Karadeniz Technical University,

Trabzon, Turkey.

[2]Ronesans Holding; Chief Sustainability Officer, Istanbul, Turkey.

Corresponding Author:

Xhensila Thomollari, PhD Student
Department of Civil Engineering
Faculty of Engineering
Karadeniz Technical University
61080 Trabzon, Turkey
Tel: +90 545 913 0965
E-mail: xthomollari@yahoo.com

ABSTRACT

The increase in world's population, rapidly social and economic developments and environmental changes are some of the most significant reasons that are leading to water crises. Governments have encouraged appropriate strategy for sustainable water management especially for building since buildings are responsible for 13% of water consumption. Therefore, designing and constructing water efficient buildings gained importance recently. This paper aims to explore the latest methods for improving water sustainability in buildings and show the benefits via case study. Recent successful experiences indicate that green buildings can reduce water consumption up to 40 % as proved in the case study.

Keywords: innovative wastewater technology, sustainable building design, water conservation.

INTRODUCTION

Statistics have showed that the growth of world population cannot be compensated with the current water availability in the world. In various research papers, it is highlighted that the increased population of our planet, the economic development, and climatic changes are causing water availability crisis. Due to various policies emerged by different governments and global organizations, the concept of water sustainability has gained a great importance. In buildings, water sustainability means utilizing limited water resources in a sustainable way to realize more functions and make those more efficient by recycling or water harvesting. Water sustainability focuses more on reducing water "waste" without increasing customer demands. For improving water sustainability in buildings, new methods need to be applied as follows: rainwater harvesting, greywater recycling, water-wise landscaping, flush and flow fixtures.
Nowadays, modern living style requires water usage at a greater level. The daily amount of water consumed by a person is defined in a range of 300 – 380 liter (in Turkey 203 liter in 2014) (1-3). According to Abdallah et.al. (4) buildings are responsible for 13% of water consumption. Depending on the functionality of the building, typical water consumption in home and office buildings are shown in Fig. 1, (5-6).

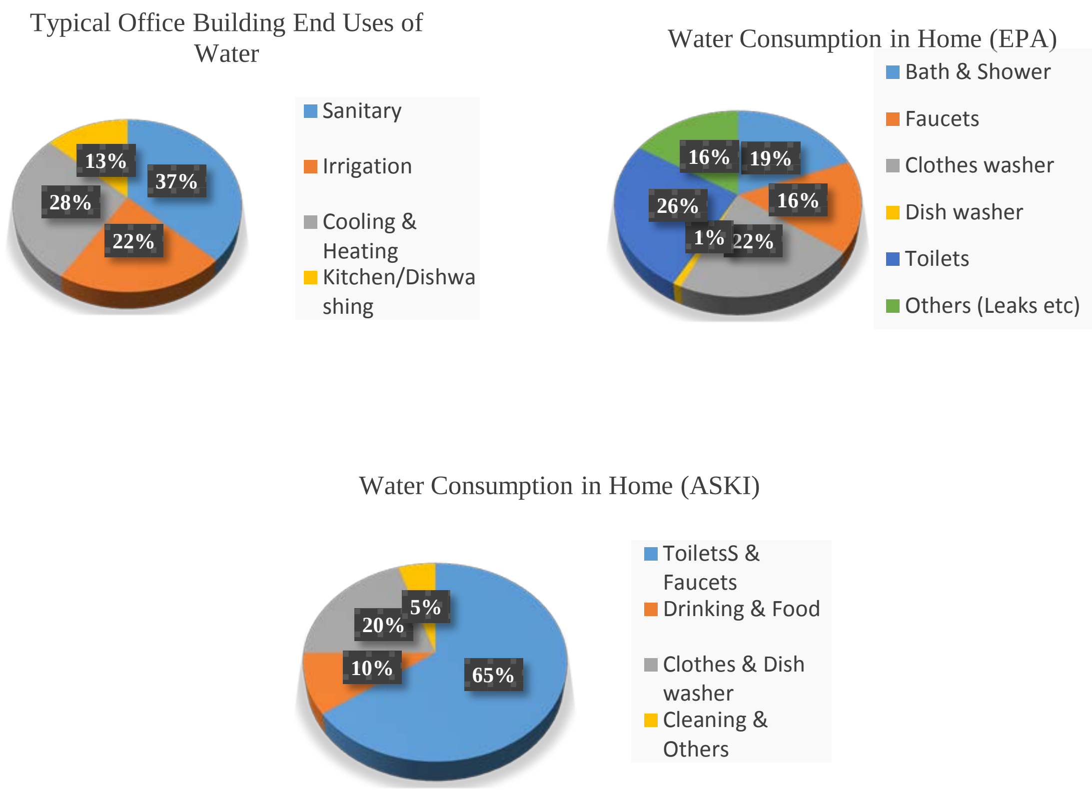


Figure 1. Typical water consumption in home and office buildings

As shown in figures, a significant amount of water is used for toilets and faucets. Since toilets and faucets can utilize imputable water, various technologies are implemented in residential or commercial buildings. Global environment protection agencies have conducted strategies to make the demand from the population more responsible for the water waste. Similarly, several agencies such as EPA (Environmental Protection Agency) encourage using monitoring water meters and installing WaterSense label products and other high-efficiency restroom fixtures. In United States, the installation of these WaterSense label facilities is mandatory. "Water Sense is an Environmental Protection Agency (EPA) program designed to encourage water efficiency in the United States through the use of a special label on consumer products that was launched in June 2006. Products that seek the Water Sense label must: i) achieve national water savings, ii) provide measurable results, iii) perform as well as or better than similar products in the same category, iv) be water-efficient, using at least 20 percent less water than EPA's fixture-specific water use baseline (7). In the following section, the methods for improving water sustainability in buildings are explored.

Methods for Improving Water Sustainability in Buildings

1. Rainwater harvesting system

Because of water crises phenomena, in some rural countries, drinking clean water has become a luxury. Nowadays, potable water is a depleting resource. Potable water is not always available and in many cases it is only possible with high initial and maintenance cost which makes it impossible to implement. Rainwater is a renewable source and relatively drinkable after a proper treatment. Rainwater harvesting saves high-quality potable water sources and it is a suitable solution for decreasing the high sewage level, mitigating floods, and soil erosions. Rainwater harvesting system is a method designed to help in potable water reduction by collecting and accumulating the rainwater via tubes in tanks and then using it for different purpose that require low-quality water as irrigation, toilet flushing etc. (8). Also, after disinfection process can be used as potable water. A rainwater harvesting system generally is composed of a collection (catchment) area, a conveyance system consisting of pipes and gutters, a storage facility, a delivery system consisting of a tap or pump, and a disinfection system (optional). In many examples, the advantages of this system were investigated by conducting Life Cycle Assessment and Life Cycle Cost Analysis. This system is advised to implement because of being a reliable source of clean water. However, the effectiveness of the rainwater harvesting systems depends on the regional annual rainwater amount and the life cycle cost of its installation (9).

2. Greywater recycling

Greywater is defined as being wastewater generated from wash hand basins, showers, and baths, which can be recycled on-site and then used for WC flushing, landscape irrigation, and other non-potable uses. Greywater does not include wastewater discharge from laundry, dishwashers and kitchen sinks due to the high nutrient levels. Bathroom's discharges are classified as wastewater with fecal contamination.

The amount and quality of greywater will in part determine how it can be reused. Irrigation and toilet flushing are two common uses. Greywater is suitable for irrigating lawns, trees, ornamentals, and food crops. Though irrigation methods in greenhouses may differ greatly from outdoor irrigation, several guidelines for use of greywater are applied to both situations. Toilet flushing can use considerable amounts of greywater, as it normally accounts for up to 50% of indoor water use (10). Low-quality greywater is not a problem if it is used for toilet flushing because the water goes into the sewer or septic system. The components of a greywater recycling system are as follows: greywater collection, conveyance system, treatment system, storage facilities, and using recycled greywater.

The advantage of greywater recycling consists in reusing the amount of water wasted during daily life which represents around 40% of daily water consumption for a person. One of the greatest concerns with greywater recycling is the potential health problem because of inadequate disinfection treatments (11).

3. Water wise landscaping

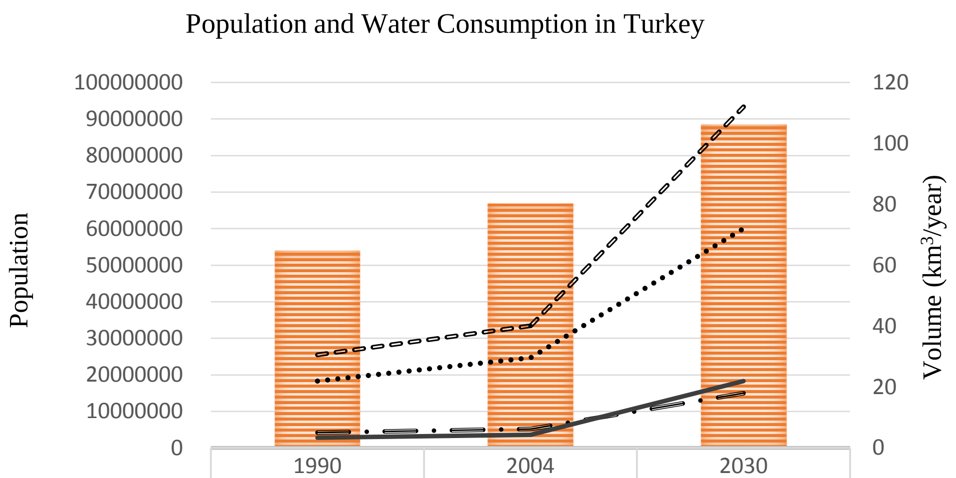
Water-Wise landscaping means quality landscaping that conserves water and protects the environment. Water-Wise landscaping is based on several basic principles such as: planning and design; soil preparation; wise plant selection; practical turf areas; efficient irrigation etc. This kind of landscaping creates a lush, beautiful landscape that saves time, money and energy, and prevents water pollution and water waste (12).

4. High Water Efficiency Fixtures

Good sustainable designs need to be fulfilled by efficient facilities. The importance of using water efficient flush and flow fixtures to improve water sustainability primarily embodies the following four aspects: reducing the volume of water consumption in unit time or per flush without bringing down the performance, improving the water efficiency, reducing the waste of water caused by unnecessary leakage, reducing water use helps reduce the energy consumption in water supply and drainage. To judge if a fixture is water efficient, we need to compare its water consumption with the baseline which can be considered as the standard value. The installation of this facilities decreases the water supply cost (13).

Water Management in Turkey

Related to water resources, considering the large population and the developed economy, Turkey is defined as an unprosperous country (14). By international standards, with a renewable water resource potential of 3,500 m^3 per capita per year, Turkey is considered as water stressed country (15). Despite being a country that faces water supplying problems, due to the incapacity of coping with the demand of an increased population, insufficient measurements have been undertaken by the Turkish Government or related national authorities (16-18). By using forecasted data, to illustrate the population's growth and the domestic sector water consumption in Turkey is demonstrated in Fig. 2, (19-21).



	1990	2004	2030
Population	53994605	66845635	88427604
Total Water Consumption (km3)	30,6	40,1	112
Irrigation (km3)	22	29,6	72
Potable/Nonpotable water (km3)	5,1	6,2	18
Industry (km3)	3,4	4,3	22

Figure 2. The growth of the population and water consumption in Turkey

However, influenced by different global environment policy, the number of commercial green buildings has increased in Turkey in the last decade. Leadership in Energy and Environmental Design (LEED) is one of the most important green building certification programs used recently. This certificate is given by U.S. Green Building Council (USGBC). It includes a set of rating systems for the design, construction, operation, and maintenance of green buildings that aims to help owners and operators to become environmentally responsible and to use resources efficiently. Recently, the number of buildings in Turkey, which have obtained this certification, has significantly increased as shown in Fig. 3, (22). These statistics put Turkey within the top 10 countries which have the greater number of the LEED certified buildings.

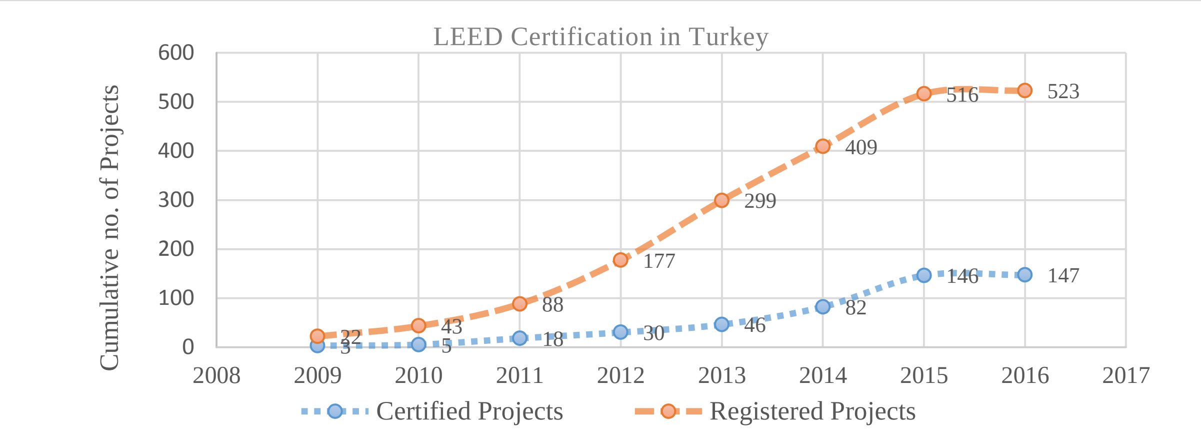


Figure 3. The number of project registered to obtaining LEED Certification in Turkey

CASE STUDY

1. Methodology

In this section, a platinum LEED certified commercial green building is analysed. Among the numerous green building in Turkey, The Rönesans Tower building was selected. This project was the first high rise building certified in Core & Shell Platinum and achieved maximum possible points in water efficiency category which makes this building a very good example for the rest of the buildings in Turkey. This research aims to introduce the innovative wastewater technology used during the design and construction of this commercial building. A survey is conducted and the rest of the information is collected from public sources.

2. The Rönesans Tower

The Rönesans Tower project was designed to meet LEED Platinum standards. The Rönesans Tower is a Class A high-rise office and the first tall structure in Turkey to receive the LEED Platinum Certificate by the US Green Building Council. The 186-meter-tall Rönesans Tower is located on the Asian side of Istanbul, at the intersection of two major highways where the two continents connect. General information of the building are shown in Tables 1-3 (23).
Some of the main amenities available within the building property line are as follow: restaurant & cafes; convenience store; dry cleaner; copy centre; shoeshine & repair; meeting rooms; showers and changing Rooms; gardens, sky gardens and landscaping etc. The average number of persons per day that use the building is 1369 (in LEED calculations).

Table 1. General information of Rönesans Tower Building

Location	Kozyatağı/Istanbul, Turkey
Building Standard	A+ Class Office building
Total Construction Area	85.000 m^2
Architecture design	FxFowle Architects/USA
Total Number of Floors	44
Gross Floor Areas	900m^2-1400m^2
Certificate	LEED Platinum
Platinum LEED Awarded Date	September 2014 / Score (81/110)

Table 2. LEED certification scorecard of Rönesans Tower

Rönesans LEED scorecard	
Total points *	81
Sustainable Site	27
Water Efficiency	10
Energy & Atmosphere	19
Material & Resources	6
Indoor Environmental Quality	11
Innovation in Design	4
Regional Priority	4

**out of possible 110 points*

Table 3. LEED credits in Water-Efficiency in Rönesans Tower Building

LEED credits in Water-Efficiency	Obtained (Yes/No)	How many points?	Implemented Technology	Water Reduction
Water Use Reduction – 20% reduction (prerequisite)	Y	-	-	-
WEc1 Water Efficient Landscaping (Up to 4)	Y	4	Stormwater management + efficient landscape design	59.77 %
WEc2 Innovative Wastewater Technologies (Up to 2)	Y	2	Efficient water closets	52 %
WEc3 Water Use Reduction (Up to 4)	Y	4	Efficient water fixtures (including water closets)	48.39%

Landscaping water consumption has been cut in half (50%) through the landscape design by using native and adaptive plants that require less water, along with an efficient irrigation system. Rainwater collection system (Innovative Waste Water Technology) collects the rainwater over the land and the stored water is to be used for the landscape irrigation system. Excessive rainwater is diverted to wells that are in connection with the natural ground and recharging to the groundwater back to its natural source. When the capacity of storage is full, excessive water is filtered before being discharged to the municipal storm water system. Water consumption for waste conveyance has been cut in half (50%) through the use of water-efficient toilets and urinals. A 45% increase in water efficiency has been achieved by installing water reducing fixtures throughout the building. The results of the questionnaire survey are shown in Table 4 and 5.

Table 4. List of low flow fixture used for indoor strategy

Fixture List	Brand	Code	Volume (gal/cycle)	Flow rate (gpm)
Dual flush water closet	Vitra	740-5800-02	0.6-1.1	--
Urinal	Vitra	6202	0.25	--
Metering public lavatory faucet	Artema	A47004STA	0.1	--
Shower	Artema	A45546	--	1.6
Kitchen sink	Artema	A40798STA	--	1.5

Table 5. The result of the questionnaire survey, the water reduction percentage for different category

		Percentage Reduction
Stormwater Management – Outdoor Strategy		
Annual captured storm water	6995.6 (m^3/year)	23 %
Annual used storm water	1604.46 (m^3/year)	
Water Efficient Landscaping		
Potable water		100%
Total water		59.77%
Innovative Wastewater Strategies		
Total calculated flush fixture water use annual volume, baseline case (kGAL)	1398.08	52%
Total calculated flush fixture water use annual volume, performance case (kGAL)	670.81	
Water Use Reduction		
Total calculated fixture water use annual volume, baseline case (kGAL)	2232.31	48.39%
Total calculated fixture water use annual volume, performance case (kGAL)	1152.11	

The parameters that were used in indoor water use calculation are shown in Table 6.

Table 6. Parameters used for indoor water use calculation

Baseline Case: Annual Work Days (260 days)				
Fixture Type	Consumption	Daily Uses	Duration	Occupants
1.6 gpf toilet - male (gallons per flush)	1.6	1	1	700
1.6 gpf toilet - female (gallons per flush)	1.6	3	1	700
1.0 gpf urinal - male (gallons per flush)	1	2	1	700
Commercial Lavatory Faucet - 0.125 gpf	0.125	3	1	1400
Kitchen sink - 2.2 gpm	2.2	1	0.1	1400
Showerhead - 2.5 gpm	2.5	0.08	8	1400

Consumption values based on fixtures and fixture fittings installed : Annual Work Days (260 days)				
Fixture Type	Consumption	Daily Uses	Duration	Occupants
0.6 gpf toilet - male (gallons per flush)	0.6	1	1	700
0.6 gpf toilet - female (gallons per flush)	0.6	3	1	700
0.25 gpf urinal - male (gallons per flush)	0.25	2	1	700
Commercial Lavatory Faucet - 0.1 gpf	0.1	3	1	1400
Kitchen sink - 1.5 gpm	1.5	1	0.1	1400
Showerhead - 1.6 gpm	1.6	0.1	8	1400

In the following section, a cost analysis was conducted. The information, used in Table 7, about the annual water volume used in the building for indoor propose, was obtained from the questionnaire survey. Also, the unit water price for potable water price applied for office buildings located in Istanbul was defined 10.01 TL/m^3 according to Istanbul Municipality /Istanbul water and sewage management authority (24).

Table 7. The annual potable water consumption cost for indoor usage

Indoor Water Consumption	Volume (Kgal/year)	Volume (m^3/year)	Water Price (TL/m^3)	Total Cost (TL/year)
Total calculated fixture water use annual volume according to baseline use	2,232.31	8,450.19	10.01	84,586.36
Total calculated fixture water use annual volume according to performance use	1,152.11	4,361.20	10.01	43,655.58
Annual savings	1,080	4,088.99		40,930.78

Accordingly, the implementation of innovative wastewater technology within a building reduces the amount of potable water and has a significant impact on the annual water supply cost. Consequently, approximate 48% of total water use reduction was achieved by installing low flow fixture in the Rönesans Tower. The decreased amount of water is converted to 40,930.78 TL annual cost savings.

CONCLUSIONS

This research proved the use of better water management and provided innovative wastewater methods by utilizing a case study. Nowadays, the global water crisis is one of the main problems that humankind is facing. That's why international environmental organizations are imposing several mandatory policies in different aspects with the scope of better water management by reducing the potable water use. In previous researches, different methods for improving water sustainability in buildings are analyzed and their advantages are highlighted. Based on the literature review, the aspect of Turkey as being unprosperous water country and having the lack of sufficient measurements for water conservation are is pointed out. However, Turkish Construction Industry recently utilized green certificate process as a way to cut water consumption. Recently, private investors, with the aim to be more competitive in the market, intend to design and construct building by integrating sustainability principals. By the literature review, it is implied that government should impose a mandatory policy for the public and private sector for an adequate water management. The case study analyzed in this paper should help the private investor and public authorities to understand the advantages of sustainable design building from the economical aspect by implementing innovative technology as low flow fixtures.

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