



Towards Achievement of SDG 6 in Campus: A Sustainable Water Management Case Study from Qassim University

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Abstract. Qassim University is in Mulaida, Qassim, Saudi Arabia.

The scarcity of potable water is one of the major environmental challenges, not only in Qassim but also across most of the kingdom. Therefore, the university has adopted a water conservation program to preserve water and make it more efficient in all its facilities. To achieve this, the university implements measures and innovative technologies for the effective use of water. This includes producing drinking water from a desalination plant established by the university with the highest specifications and supplying it to the campus facilities. Additionally, wastewater treatment is carried out to ensure safe use for irrigation purposes within the university's landscaped areas. The university also rehabilitates several wells while designing and dividing irrigation zones and supervises and monitors tree planting and green areas. Furthermore, there are plans for a water recycling plant and the installation of pipelines to transport recycled water for irrigation in the university's green

fields. The university buildings are also equipped with laboratories that employ neutralization methods to treat hazardous waste. The water management program at Qassim University contributes to providing advanced solutions and applications regarding the role of sustainable universities in managing water resources. Therefore, the study highlights the importance of technology and innovation in preserving and utilizing resources in higher education institutions. Qassim University serves as a good example for universities within and outside the kingdom that address water scarcity and promote sustainable practices both within and outside the campus.

Keyword:

Sustainability, SDG 6, Water management, Sustainable campus, Qassim University

1. Introduction

Higher education institutions, such as universities, play a crucial role in teaching, research and process sustainability. It also plays a role in promoting sustainability beyond its walls, taking responsibility for society's problems and helping it find solutions that are integral to sustainable growth. Cooperation and interdependence between universities and decision-makers Research and information contributions have a positive impact on regional sustainability. Furthermore, stakeholders and local governments are working to strengthen universities to achieve their role, responsibility and commitments in the field of sustainability [1].

In addition to research and academic curriculum, higher education institutions and universities can practically present the most impactful ideas and concepts to society towards the shift to sustainable thinking and raise awareness of the importance of applying sustainability. They can also do this by implementing positive environmental best practices in campus buildings, which should generally aim to minimize negative environmental impacts. [2]. Sustainability strategies in higher education institutions are driven by two important objectives: the first goal is to raise awareness of sustainability issues, while the second goal aims to use technology to mitigate environmental burdens at the local and global levels [3].

At Qassim University, the first goal was achieved by organizing many seminars, workshops and conferences that contributed to raising awareness of sustainability issues. The second goal was achieved by applying a variety of technologies that help reduce environmental burdens within the university and the surrounding community. Qassim University has joined the sustainability program that aims to promote sustainability. Currently, the university ranks 153 out of 1050 [4], (see figure 21). A sustainability centre has been established to coordinate and implement projects and initiatives submitted to the university or by it to the community. Within the scope of this study, some of the practices used by the university for water use management will be presented.

2. Evaluation

The evaluation is based on green architecture standards through a set of systems related to the environmental performance of the building or place to be evaluated [5]. Examples of evaluation systems are LEED, PEARL and PREEAM. They are systems dedicated to the evaluation of buildings. The UI Green Metric system is used to evaluate universities.

3. The role of universities in achieving sustainability

3.1. Advancing the Sustainable Development Goals (SDGs):

In 2014, UNESCO held the World Conference on Education for Sustainable Development, which inspired university researchers to conduct research on sustainability [6]. Now, most higher education institutions apply sustainability in their campus activities [7]. Higher education institutions must therefore increase their work and assess their progress in advancing the Sustainable Development Goals (SDGs).

Saudi Arabia is among the countries encouraging higher education institutions to apply sustainability in their operations as well as in their programs [8]. In line with both Saudi Vision 2030 and the Saudi Green Initiative, all Saudi higher education institutions are working to implement the Sustainable Development Goals. A recent UN report on the progress of universities in Saudi Arabia in achieving the Sustainable Development Goals and Saudi Vision 2030 [9] has been published. One of the most important SDGs is SDG 6 "Clean Water", as Saudi Arabia is in the most water-stressed region in the world.

3.2. UI Green Metric World University Rankings

In 2019, Indonesia held an international conference on issues of quality of education and rankings of world universities [10].

The idea of UI Green Metric is to provide a set of online checklists to assess the state of the university, and sustainability policies proposed and implemented at universities around the world [11]. This system was created in 2010 to assess the current state of universities around the world and plans to improve them so that they become more environmentally sustainable. The evaluation includes six criteria [12]: Setting & Infrastructure (relative weight 15%); Energy & Climate Change (21%); Waste (18%); Water (10%); Transportation (18%), and Education (18%).

For each of the six standards, a set of indicators has been developed to be used when measuring. For example, the water standard has four indicators, including: Water conservation and recycling (300 marks each); Water efficient appliances, and treatment (200 marks for each). For a total of 1000 marks, representing 10% of the total evaluation.

The research aims to study the sixth goal of the Sustainable Development Goals (SDG 6) related to the provision of clean water and sanitation for all by recognizing the fundamental importance of access to safe and clean water resources. In Saudi Arabia, addressing water waste and ensuring sustainable water management is essential given the region's arid climate conditions. Qassim University's commitment to the sixth goal of the Sustainable Development Goals is demonstrated through its initiatives to maintain water by applying a set of measures to reduce water consumption on its campus, and this will be explained in the research.

4. Methodology

The research follows the inductive approach by talking first about the role of universities in achieving sustainability and then addressing the sixth sustainable development goal related to clean water and sanitation by studying ways to conserve water on campus in general, and Qassim University specifically (as a case study). Then presenting the university's initiatives to conserve water such as installing water-saving equipment, treating water and using it for non-potable purposes, Holding awareness campaigns, workshops, and others. To reach the results and recommendations that must be followed in the future.

5. Water Conservation in Campus /Qassim University

Conserving water usage in campus can be achieved through several strategies and initiatives. Here are some key steps that can be taken:

5.1. Promoting awareness on campus

By launching awareness campaigns among (students, staff and faculty members) at the university to introduce the importance of water and ways to conserve it [13]. On the other hand, holding seminars and workshops inside and outside the college in addition to awareness campaigns on social media platforms [14].

Qassim University has activated some of these practices, whether by holding courses and events that resulted in increasing the knowledge of students and the community about aspects of water sustainability and ways to conserve it. This was done with the participation of some directors and faculty members of the university. These events are invited within the university through the university email for students and official announcement platforms on the university's website. and outside via social media platforms.

5.2. Fixtures and equipment

The use of effective water devices and the repair of malfunctions and leaks that occur in them through periodic and regular inspection of them, whether inside the university buildings or in the irrigation systems used in green areas, will improve water use and reduce waste. Besides, water-saving devices such as timed or sensor-activated water sources, and low-flow toilets should be used [15]. As in Point 5.16

5.3. Water-saving landscaping

This is done using local green elements that require small amounts of irrigation water and are drought-resistant [16], as well as using advanced irrigation methods equipped with timers and sensors [17]. Figure 2.

5.4. Water recycling and reuse

Water is recycled after treatment [18], such as greywater reuse and use in irrigation operations and other uses of non-potable water [19].

5.5. Improving irrigation practices

Through periodic and regular inspection of the irrigation systems used and the treatment of any malfunctions or leaks [20]. In addition to the use of irrigation timers at specific times according to the surrounding weather conditions [21]. At Qassim University,

this is done at specific periodic intervals in accordance with the contract signed between Qassim University and the contracted maintenance companies.



Figure 1. Right (The Director of Qassim University launches the "Qassim Green Land" initiative to plant 6000 trees inside the university city, and 3000 outside it irrigated with recycled water), middle (the participation of university students in afforestation of their college and irrigating it with recycled water) Left (The university launches the initiative of the Prince of Qassim in its third phase to increase interest in afforestation and irrigation with recycled water in Qassim).

Source. <https://t.co/JmkDcNatoD> / X



Figure 2. Left (irrigation using irrigation timers), centre (subsurface irrigation to reduce waste in water use) right (irrigation early to reduce waste in water use).

Source. <https://qu.edu.sa/>

5.6. Human Behavioural Change

Students are encouraged and urged to use practices that conserve water on campus, such as moderate use of water, shutting off water sources after use or when not in use, and reporting malfunctions or damage that may occur in bathrooms or green irrigation areas on campus [22].

5.7. Policies and Practices

A set of policies and practices related to water efficiency on campus should be implemented, including in several ways, including setting general water use targets in all university colleges, using water consumption measuring devices, and rewarding one or more water conservation initiatives [23].

5.8. Curriculum and water conservation

Water conservation methods should be included in the relevant curriculum, courses or seminars offered by the university, to encourage students to promote a culture of water conservation and raise environmental awareness among them.

At Qassim University, water conservation methods have been included in the study programs of some relevant colleges such as the faculties of agriculture, science, and soil engineering, in addition to holding relevant seminars and events.

5.9. Community Participation for Water Conservation:

The university collaborates with local communities through awareness programs that promote water conservation.

Qassim University collaborates with schools and community and local centres organizations to raise awareness, provide educational resources and encourage water provision [24]. See Figure 3.



Figure 3. Right (Qassim University's Fourth Sustainability Campaign "Awareness, Health and Education" held in Al-Asyah Governorate), centre, and right (Qassim University's summer club initiative "My Environment is Green" for club members in order to enhance awareness towards the environment and contribute to the Saudi Green Initiative in sports halls in the university city).

Source. <https://t.co/u1Hp3anYFi> / X

5.10. Water Salads

The competent authorities within the university must communicate continuously with the water authorities, especially local ones, to obtain new initiatives to be implemented to conserve water, obtain grants or rewards provided for water conservation projects or initiatives, and partner in the fields of research and awareness campaigns.

Qassim University has carried out many projects with internal and external parties, including cooperation with the Ministry of Environment, Water and Agriculture, where the university received on 6/7/1442 AH a delegation from the Ministry of Environment, Water and Agriculture, where the two parties held a second meeting to activate the memorandum of understanding between them to discuss cooperation in the fields of environmental preservation. This meeting comes in implementation of the memorandum of understanding signed between the two sides in an effort by each party to benefit from the capabilities and expertise of the other party. The meeting discussed the tasks of the members of the two groups, the efforts made by each party in raising awareness of the need to preserve the environment and increase green land and ways to achieve integration between them for the benefit of society [25]. Figure 4.

As well as cooperation with the National Water Company represented by the Northern Region to implement a water supply project to serve subscribers in various regions in the Qassim region at a cost of more than 65 million riyals. For the implementation of this project,

320 kilometres of pipes and 1,034 local extensions were installed. The project provides water to many villages, districts and centres in different parts of Qassim, including Muthanab, Al-Rass, Nabhaniya, Oyoun Al-Jawa, Riyadh Al-Khebra and Buraidah [26].



Figure 4. Activities of the university's meeting with delegations from the Ministry of Environment, Water and Agriculture.

Source. <https://t.co/u1Hp3anYFj> / X

5.11. Monitoring and evaluation

By regularly monitoring the behaviour of water consumption within campus buildings and in outdoor green areas, it is possible to identify areas where the university needs improvements, thereby saving water and improving use over time [27].

In Qassim University, this is done at periodic intervals according to the contract between Qassim University and the contracted water company.

5.12. Research

The university's research efforts should extend to water treatment and purification technologies.

Qassim University Vice Deanship for Graduate Studies and Scientific Research, represented by the Innovation and Intellectual Property Centre, encourages university employees to submit research projects on water conservation, whether as individuals or groups, as well as in cooperation with other universities.

The university has received many awards in this field, including obtaining a patent document from the Saudi Authority for Intellectual Property, for the invention of "a system and method for desalination of water using a halophyte plant", through a closed biological system that can convert highly saline water into distilled fresh water, so that the system works naturally and can produce fresh water in commercial quantities.

The research team was able to create this system, which works for a long period of time without the need for any intervention, which helps solve the problem of desalination in a sustainable manner, using solar energy without the need for other energies [28].

5.13. Water Treatment

The university should offer effective methods of water treatment and purification that depend on scientific research and continuous development.

Qassim University contributes to the development of effective and sustainable methods of wastewater treatment, improving water quality, and ensuring that water resources remain safe for consumption and use, as all university wastewater is treated by a

wastewater plant for recycling and reuse again for agricultural purposes as follows

5.13.1. Water Recycling

Qassim University has established a station whose purpose is to recycle water using advanced technologies that treat wastewater and then use it for other non-drinking purposes [29].

All sewage water of the main campus of Qassim University are recycled and treated to be suitable for agriculture purposes. Monthly average of recycled water is 8700 m³ per month that are used for irrigating plants. Figure 5.



Figure 5. Water Recycling Station in Qassim University

Source. <https://maps.app.goo.gl/djRbEybn7eThTifXA>

The water and sewage treatment Station at Qassim University follows all the specifications of the Standards Authority, which produces water suitable for irrigation and not harmful to green areas and trees. By reviewing the laboratory analysis results, it is possible to read the average properties of the water leaving the station, and the average properties of the water entering the station. There are some special analyses such as: Average suspended solid water (TTS); Average chemical oxygen requirement (COD), and Average dissolved oxygen (DO).

Below is a presentation of the monthly flow rate of treated water for the academic year 2021-2022. See Table 1.

Table 1: Average monthly flow of treated wastewater at the treatment station during the academic year 2021 - 2022.

The approximate monthly flow rate of the water treatment plant during the past academic year/meter³	8700 M³
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Table 2: Average properties of water entering the treatment Station during the academic year 2021 - 2022.

Average suspended solid water (TTS)	Average chemical oxygen requirement (COD)	Average dissolved oxygen (DO)
353 PPM	352 PPM	2.01 PPM

Table 3: Average properties of water leaving the treatment Station during the academic year 2021 - 2022.

Average suspended solid water (TTS)	Average chemical oxygen requirement (COD)	Average dissolved oxygen (DO)
1.98 PPM	20 PPM	5.02 PPM

5.13.1.1. Stages of wastewater filtration

1. Mechanical strainers: their role is to remove solid materials.



Figure 6. Mechanical strainers in Qassim University

2. The primary sedimentation stage: In which impurities and sludge are deposited.



Figure 7. The primary sedimentation stages.

3. Biological treatment (Aeration basins): provides oxygen to oxidize and precipitate organic materials and then dispose of them.



Figure 8. Aeration basins.

4. Final settling basins: In which sludge and impurities are settled.



Figure 9. Final settling basins.

5. Sand filter: Contains 6 different layers to remove all remaining small and ultra-fine impurities.



Figure 10. Sand filter.

6. Sterilization unit in which chlorine is pumped to sterilize irrigation water in Irrigation water tanks with a capacity of 2500 m³.



Figure 11. Irrigation water tanks and Sterilization unit.

7. Pumps for pumping treated water for irrigation.



Figure 12. Pumps for pumping treated water.

After treatment, the water is used for various irrigation purposes within the Qassim University campus, including all green areas of the university, which helps preserve fresh water sources.



Figure 13. Irrigation green areas within the Qassim University campus.

This program includes a piping network to distribute water after circulation to ensure smooth supply to designated areas, which helps increase the quality of use and reduce waste.



Figure 14. Monitoring distribution water Piping network in Qassim Campus.

5.14. Water pollution control in campus area

The water conservation policy in Qassim university is focused on both the water used inside campus as well as the water used for irrigation in the Agricultural experimental station. In which the water is tested regularly to ensure its quality and as a measure of water pollution control.

There is an equipped lab for water analysis inside the water recycling station inside the university. Figure 15. This lab is watching the quality of water in several stages. The main water source is tested in several points to confirm its quality. On the other hand, there is another lab inside College of Agriculture and Vet. Medicine, in which it controls the quality of the irrigation water which is used in the Agricultural experimental station in a regular base.



Figure 15. The laboratory of the university's water treatment station.

5.15. Treating toxic wastes.

All buildings that contain laboratories are equipped with neutralization tanks for treating toxic wastes. Figure 16.

5.16. Use of Water-Efficient Appliances

By implementing the effective use of electrical equipment, Qassim University has been able to minimize water use on campus by over 81%.

- Automated hand washing taps installed in all colleges.
- Highly Efficient dual flush installed in all colleges. (>81% Of water efficient appliances installed). Figure 17 and 18.

5.17. Seminars & Conferences

The university will hold many local and international seminars and conferences related to water conservation.



Figure 16. Copy of material submittal/ Request for material approval (Neutralization tanks) in Qassim University.



Figure 17. Automated hand washing taps in Qassim University.



Figure 18. Some water efficient appliances in Qassim University.

5.17.1. First International Conference on Natural Resources Sustainability

Qassim University held the first international conference on the sustainability of natural resources under the title "Sustainable Management of Solid Materials and Waste" in the period from 8-9/3/1441 AH (for two days), which was organized by the College of Engineering Sciences at the university and the Centre for Sustainable Development at the university's headquarters with the participation of 36 speakers to cover all axes of the objectives of this scientific meeting. Figure 19.

5.17.2. Network Water Quality Conference in Buraidah

Qassim University held a network water quality conference at the King Khalid Cultural Centre in Buraidah from 7-9/10/2018 (for three days), where three dialogue sessions were held, which included 8 working papers, all related to water quality as follow (Figure 20):

- The first paper discussed the topic of "groundwater quality"
- The second is entitled: "Plastic pipes in which drinking water is used in networks and homes"
- Third: "Desalination Industry in the Kingdom of Saudi Arabia",
- Fourth: "Promising Desalination Methods"
- Fifth: "Optimal design of water purification plants to reduce waste generated by wastewater",
- Sixth: "Specifications of transported water and its impact on the life span of transport systems and its reflection on the quality of water reaching the consumer",
- Seventh: "Protection of buried carbon iron pipes used in water transport from corrosion",
- Eighth: "Monitoring of organic and inorganic substances and pollutants in produced water".



Figure 19. First International Conference on Natural Resource Sustainability entitled "Sustainable Management of Solid Waste"



Figure 20. Network Water Quality Conference in Buraidah

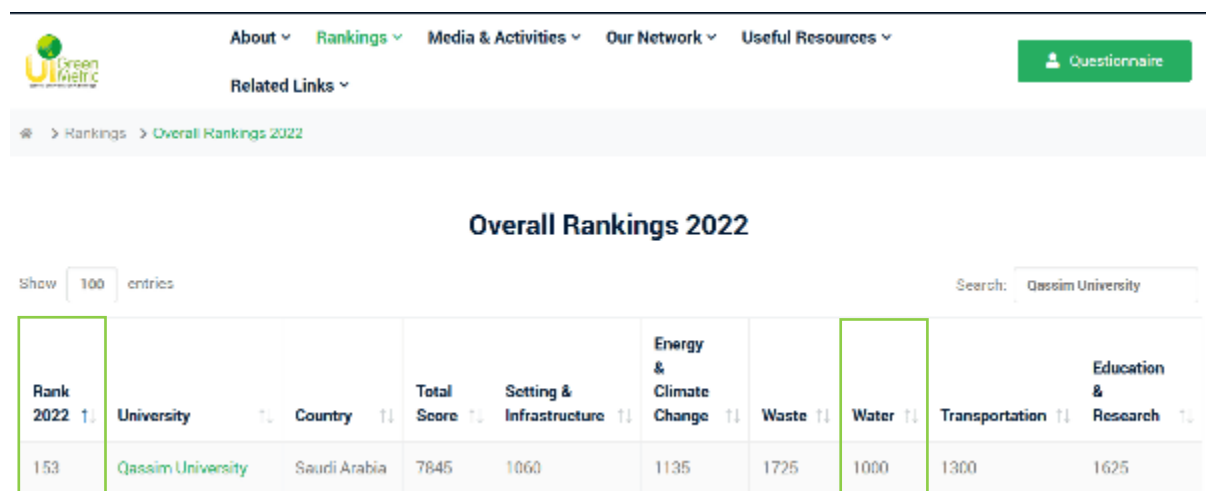
6. Conclusions

Sustainable Development Goal 6 (SDG 6) is to ensure access to clean water and sanitation for all, recognizing the fundamental importance of access to safe and clean water resources. Qassim University recognizes the importance of SDG 6 and has embarked on initiatives to contribute to water conservation and efficient water use, the university has implemented the campus water management program, by establishing a water treatment plant and then using it for irrigation and other non-drinking purposes.

The university provided drinking water and expanded the distribution of water to multiple cities within Qassim, which led to an increase in the proportion of fresh water in

these cities, as well as reducing the waste of fresh water that was previously used to irrigate green spaces, and other wrong practices. The university held several workshops and awareness campaigns to raise awareness of the importance of rationalizing and conserving water use to achieve water sustainability on campus (among students, staff and faculty) and outside as well. The university is currently working on improving water monitoring systems and increasing technologies used in water treatment, in addition to developing regulations related to policies and practices applied inside and outside the university campus. Qassim University is keen to establish partnerships with the competent authorities in the field of water management, whether inside or outside the Kingdom, to increase environmental expertise and practices in the field of water management. The initiatives offered by Qassim University to manage water in sustainable ways demonstrate its endeavor to preserve the environment and combat water scarcity.

As a result of this good management, the university obtained full marks in water managements (1000 marks) in UI GreenMetric Ranking 2022 [4], as in figure.



The screenshot shows the 'Overall Rankings 2022' page on the UI GreenMetric website. The navigation bar includes links for About, Rankings, Media & Activities, Our Network, and Useful Resources. A 'Questionnaire' button is also present. The breadcrumb trail indicates the path: Rankings > Overall Rankings 2022. The table displays the following data for Qassim University:

Rank 2022	University	Country	Total Score	Setting & Infrastructure	Energy & Climate Change	Waste	Water	Transportation	Education & Research
153	Qassim University	Saudi Arabia	7845	1060	1135	1725	1000	1300	1625

Figure 21. Qassim University ranking in UI GreenMetric, 2022.

Also, the university's General Administration of Maintenance obtained three international "ISO" certificates in the integrated management system [30]:

- 'ISO 14001' certificate for Environmental management system (EMS).
- 'ISO 45001' certificate for the occupational safety and health system.
- 'ISO 9001' certificate for quality management system.

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