# Suggestions of water-saving measures: A Case Study of a University in southern China

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***บทคัดย่อ*** ทรัพยากรน้ำเป็นหนึ่งในองค์ประกอบสำคัญของการพัฒนาที่ยั่งยืนระดับโลก อย่างไรก็ตาม ปัจจุบันทรัพยากรน้ำกำลังเผชิญกับความท้าทายร้ายแรงทั่วโลก ซึ่งรวมถึงการขาดแคลนน้ำ มลพิษทางน้ำ และอุปสงค์และอุปทานที่ไม่สมดุล มาตรการอนุรักษ์น้ำถือเป็นประเด็นสำคัญในการแก้ปัญหาทรัพยากรน้ำทั่วโลกมาโดยตลอด บทความนี้ยกตัวอย่างมหาวิทยาลัยทางตอนใต้ของสาธารณรัฐประชาชนจีนเพื่อประเมินการใช้น้ำ บันทึกมาตรการประหยัดน้ำที่มีอยู่ และเสนอการปรับปรุงเพื่อการคุ้มครองและการใช้ทรัพยากรน้ำอย่างเป็นระบบและมีประสิทธิภาพ การศึกษานี้พบคำแนะนำที่สำคัญ เช่น การเปลี่ยนระบบประหยัดน้ำแบบแมนนวลเป็นระบบอัตโนมัติ การเพิ่มมาตรวัดน้ำระยะไกลสำหรับการตรวจจับการรั่วไหล การปรับปรุงระบบน้ำร้อน และการเพิ่มการนำน้ำฝนกลับมาใช้ใหม่เพื่อการรีไซเคิลน้ำอย่างมีประสิทธิภาพ ทั้งนี้การดำเนินการที่แนะนำสามารถประหยัดน้ำได้ไม่น้อยกว่า 30,000 ตันและค่าน้ำ 135,000 หยวนต่อปี

***คำสำคัญ*** : การประหยัดพลังงาน, มาตรการประหยัดน้ำ, ระบบน้ำรีเคลม, เมืองฟองน้ำ, ระบบตรวจสอบ

***Abstract*** Water resources are one of the key elements of global sustainable development. However, water resources are currently facing serious challenges worldwide, including water scarcity, water pollution, and imbalanced supply and demand. Water conservation measures have always been an important issue for solving various water resource problems worldwide. This article took a university in southern of the People's Republic of China as an example, documented existing water-saving measures, and proposed improvements for systematic and effective water resource protection and utilization. The findings were key recommendations such as replacing manual with automatic water-saving facilities, adding a remote water meter for leak detection, renovating the hot water system, enhancing rainwater reuse and improving the effective utilization of miscellaneous water systems for efficient water recycling. Among them, effective utilization of miscellaneous water can save at least 30000 tons of water and 135000 yuan per year.

***Keywords*** Energy saving, Water-saving measures, Reclaimed water system, Sponge city, Monitoring system.

## 1. Introduction

Water resources are strategic natural resources that are crucial to human survival and sustainable development. Recently, Li mentioned that water resources have three special attributes, including scarcity in quantity, imbalance in distribution, and irreplaceability in use [1]. In 2022, the World Meteorological Organization pointed out that severe drought has affected regions including the United States, Europe, the Middle East, and the Yangtze River Basin in China; they are facing severe drought [2]. Shen's report also pointed out that a recent report released by the World Resources Institute showed that the world is currently facing serious water resource pressures, with approximately 4 billion people, or half of the world's population, experiencing high water scarcity for at least one month each year. It is expected that the proportion of the affected population will rise to nearly 60% by 2050. The report also calls on countries to take effective action and continuously strengthen water resource management to prevent further deterioration of water scarcity [3]. The three special attributes of water resources and the current global water resource situation make water-saving actions increasingly important and urgent. Higher education institutions, as an important member of society, should become a model of water-saving behavior. Various measures should be taken to achieve the goal of water.

Article 2.0.4 of the General code for design of building water supply and drainage and water saving stipulates conservation that the processes, equipment, appliances, and products selected for building water supply and drainage and water-saving projects shall be water-saving and energy-saving. Article 3.4.1 stipulates that water supply and use shall be installed according to the purpose of use, payment or management unit, item by item, and level by level, with measuring devices that meet the needs of use and have passed metrological verification. In contrast, article 3.4.4 Water distribution branch pipes with a water pressure greater than 0.2 MPa at the water consumption point should take pressure reducing measures and meet the requirements of the working pressure of the water equipment. Article 5.1.3 regulations: The centralized hot water supply system should be equipped with a hot water circulation system. The time for the outlet temperature of the hot water distribution point in residential buildings to reach the minimum outlet temperature should not exceed 15 seconds, and the outlet temperature of the water distribution point in public buildings should not exceed 10 seconds [4].

In addition, domestic water saving devices have more detailed parameter requirements for water-saving household water appliances, such as water-saving faucets (faucets) should have manual or automatic opening and closing and control of water flow at the outlet, the use of valve products that can achieve water-saving effects, water-saving toilets should use toilets with a one-time flushing water volume of no more than 6L, water-saving toilet flushing valves with delayed flushing, automatic closing, and flow control functions, and so on [5]. Furthermore, a case study by Muhammad suggested that 76% of the houses did not have water-saving devices. In comparison, the other 24% had water-saving devices such as dual flush toys, low flow high-efficiency faucet ethers, low flow plum fixtures, and automatic shut-off puzzles. A unit increase in water saving devices will lead to a 0.512 decrease in water consumption level [6].

Several researchers have paid attention to conserving water resources and usage. Wang et al. used a certain institution as a case study to set up a refined water use classification and metering hardware system, achieving automatic acquisition of water use data by region, floor, and functional area. A comprehensive intelligent water-saving monitoring hardware system was conducive to timely detecting water usage abnormalities, analyzing leakage phenomena, tapping the potential, and increasing the efficiency of water-saving work in public institutions [7].

Anchan and Prasad [8] suggested that a South Indian University could resolve the water scale issue by accumulating about 1,13678.9 $m^3$ of stormwater from a rooftop in a year and using it during the non-monsoon season. Liu and coworkers conducted a study on water-saving measures such as rainwater recycling in a Chinese university. They concluded that both water-saving and unconventional water source utilization could implemented simultaneously, resulting in (a 470,000 cubic meters reduction) of about 2.15 million yuan in water costs and reducing the operating and maintenance costs of domestic water supply and green landscape water bodies within the campus [9]. Zhang et al. proposed a long-term strategic perspective: urban recycled water should become an important aspect of the new urban water supply source. Urban recycled water irrigation for green spaces would be an important component of the urban water cycle, and the research and application of urban recycled water irrigation for green spaces will be of great significance [10]. Lu introduced the importance of the application of the Sponge City (SPC) concept as well as its problems in the building water supply and drainage design and put forward corresponding solutions hoping to help urban infrastructure construction [11]. Furthermore, an independent analysis was conducted on two cities in China as cases, and SPC measures suitable for the city were listed [12].

Zheng proposed remote control of pump room equipment through the internet or mobile internet. This system can greatly improve the management ability of urban water supply and ensure water safety, saving a lot of manpower and time [13]. The

Internet of Things was used for data analysis and visualization of the pressure data in real-time through SMS/email and provide alarms, timely detecting faults and leaks in the water supply system [14]. A leak detection system for water supply pipelines based on flow monitoring and Internet of Things technology is suitable for the timely detection of leaks in modern urban water supply systems. By installing flow meters on the inlet valves of each residential area, a total water meter, flow meter, and computer Internet of Things system for the residential area were established, and the data was summarized for analysis and detection of leaks [15]. The purpose of this study is to investigate and verify the current water use situation of the university, list the water-saving measures currently implemented by the university, and analyze and propose improvement suggestions for water-saving measures to achieve systematic and effective protection and utilization of water resources.

## 2. Materials and Methods

This study took a university located in southern China as an example. The existing data on water appliances and equipment for some typical buildings on the campus are shown in Table 1.

Table.1 Water appliances and equipment.

| **Building Name** | **Appliances/ Equipment** | **Number** |
|---|---|---|
| Teaching Building | Faucet | 141 |
| | Toilet | 203 |
| | Urinal | 108 |
| Phase I &II Student Dormitories | Faucet | 2,196 |
| | Toilet | 1,574 |
| | Urinal | 18 |
| | Shower | 1,574 |
| Business Faculty | Faucet | 63 |
| | Toilet | 95 |
| | Urinal | 34 |
| Faculty of Architecture and Design | Faucet | 123 |
| | Toilet | 99 |
| | Urinal | 48 |
| Athletics Field | Faucet | 39 |
| | Toilet | 52 |
| | Urinal | 24 |
| | Shower | 42 |

After on-site verification, all water-consuming equipment and sanitary ware listed in Table 1 were water-saving sanitary appliances, faucets, etc., all complied with the current industry standard, the domestic water saving devices CJ164-2002, and used first-level water efficiency products. The toilet adopted a water-saving toilet with a flushing capacity of no more than 6 L/time (using a 3/6 L double shift or siphon type), the urinal adopted an induction flushing valve, and most washbasin faucets used induction faucets. All faucets were made of ceramic pieces with good sealing performance and durability. However, in actual use, there were cases where manual faucets were not turned off in a timely manner.

The setting of water meters on the campus is as follows:

**Teaching and office buildings**: A water meter was installed at the main inlet pipe only, which had a remote data transmission function.

**Dormitory building**: A main water meter was installed at the main inlet pipe, and a separate water meter was installed in each dormitory room. The water meter had a remote data transmission function.

Grading measurement basically met the requirements of the general code for the design of building water supply and drainage. The schematic diagram of the water supply metering system in the dormitory building was shown in Figure 1. (taking the Phase II Student Apartments as an example).

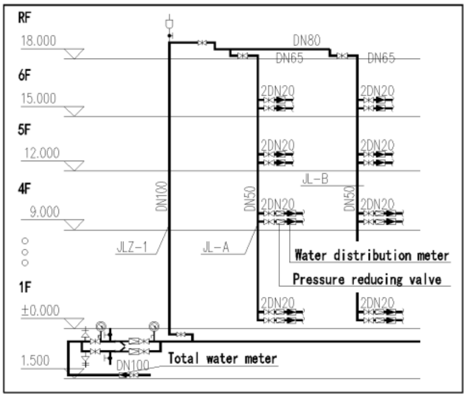


Fig. 1 The schematic diagram of the water supply system in the dormitory building.

From Figure 1, The water supply system has installed water meters according to usage, payment or management unit, item by item, and level by level. And it could be seen that the water supply method for the dormitory building was top-down, so a pressure reducing valve was installed on the floors with higher pressure to adjust the pressure to below 0.2. This measure met regulatory requirements, and appropriate water supply pressure had a positive impact on the service life of pipelines and valves and unnecessary water resource waste.

From the hot water system diagram of the dormitory building shown in Figure 2, it could be understood that the system was equipped with three thermometers, T1, T2, and T3, respectively, on the water tank, hot water supply pipeline, and hot water return pipeline. Such arrangement allowed the system to operate corresponding equipment based on the detected temperature difference, such as:

- When the thermometer T1 ≤ 55 ℃, turned on the air source heat pump hot water unit, which heats the cold water.
- When the thermometer T2-T3 ≤ 2 ℃or T1 ≥ 60 ℃, turned off the air source heat pump hot water unit.
- When the temperature gauge T1-T3 ≥ 10 ℃, opened the return water solenoid valve on the T3 side.

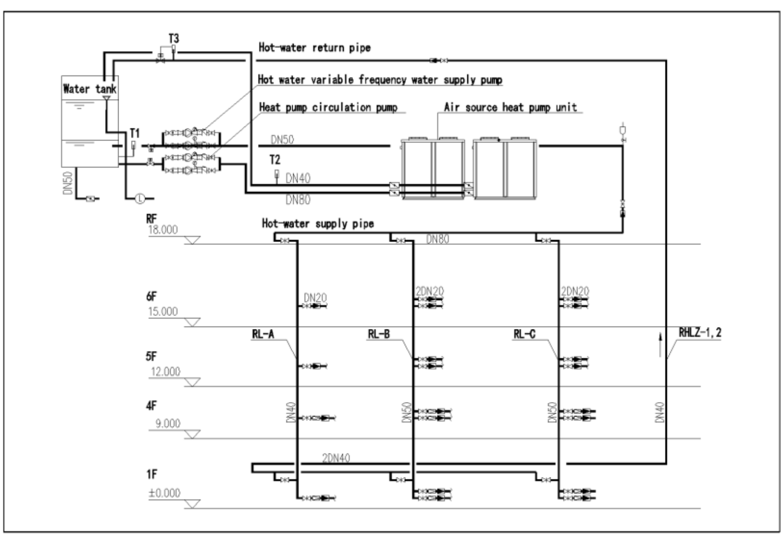


Fig. 2 Schematic diagram of the hot water system in the dormitory building.

Through continuous observation of the operation of the hot water system in the Phase I student dormitories (completed and put into use in 2015) and Phase II student dormitories (gradually completed and put into use in 2018), the average hot water outlet speed in Phase II student dormitories was about 15 seconds, which basically met the standard requirements. However, the average hot water outlet speed in the Phase I student dormitories was about 30 seconds. The reasons for the slow outlet speed were analyzed as follows:

1). The branch pipe at the end of the dormitory was not included in the return water pipeline, and the distance between the branch pipes was too long. When using hot water, it was necessary to drain this part of the cold water before hot water could be produced.

2). The setting position of some T2/T3 thermometers was not reasonable enough; for example, T3 was set at a hotter position in the return pipe, but in reality, the temperature inside the return pipe was already too low, or the thermometer had become invalid and had not been replaced.

3). Due to the age, some insulation cotton for pipelines had aged, and replacement was needed.

The university had done the following work in rainwater recycling and Sponge City construction:

1). Some buildings had rooftop gardens, and some pedestrian paths used permeable bricks.

2). A central lake had been set up in the center of the campus, which collected the surrounding mountains and rivers, natural rainwater, and rainwater from various buildings through outdoor rainwater pipes into the lake. A regulating weir had been set up and closed during the dry season to ensure the water level of the central lake. During the rainy season, the regulating weir discharged floodwaters based on the water level.

3). The newly built library (completed and put into use in 2023) was equipped with a rainwater recovery system, which collected rainwater from the buildings and the central lake and then lifted to the machine room for further treatment by a rainwater lift pump. The treated water was used for green irrigation.

4). A miscellaneous water treatment station had been set up to treat miscellaneous water for green irrigation, and miscellaneous water irrigation pipelines had been gradually built from 2010 to the present (as shown in Figure 3.).

However, there were the following issues with rainwater recycling and Sponge City construction:

1). Due to construction quality issues, the rainwater recovery system in the library could not be put into normal use. The reason was that the liquid level meter was malfunctioning, unable to automatically replenish water, supplied water, and the outdoor landscape pool was leaking, unable to store water.

2). Due to the gradual construction of miscellaneous water pipelines according to engineering projects, the quality of the pipelines varies, and there was a phenomenon of water leakage.

3). At present, the water source of the miscellaneous water pipeline was the river water around the campus rather than the miscellaneous water within the campus.

4). The campus green area was about 180,519 m$^2$, and the water treatment capacity of the miscellaneous water pump room (about 100 Ton/day) was not enough to support the one-time green irrigation water for the whole school in the dry season. The water outlet pressure (0.4 MPa) could not reach the same irrigation for the whole school (which can be divided into zones for irrigation).

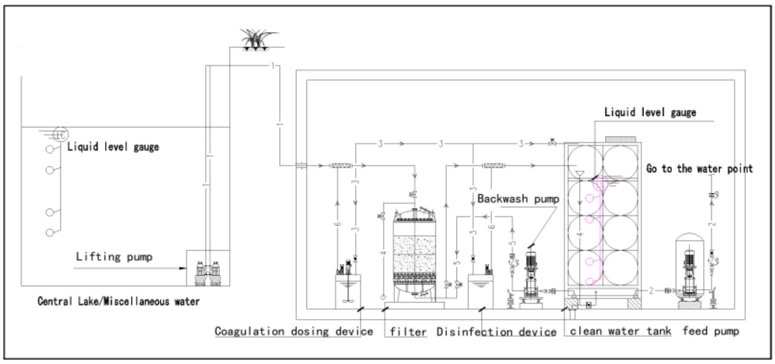


Fig. 3 Rainwater collection and reuse/miscellaneous water use process diagram.

The university built a smart water management platform in 2020 (as shown in Figure 4.); this platform combined the remote water meters installed at the entrances of various buildings, which were used for daily water supply monitoring. It could timely monitor the total water consumption and detect abnormal water use, pressure anomalies, and the range of water supply leaks.

After the smart water management platform was put into use in 2020, a total of 28 pipeline leaks were detected by the platform in 2021 (as presented in table 2), and timely repairs were made.

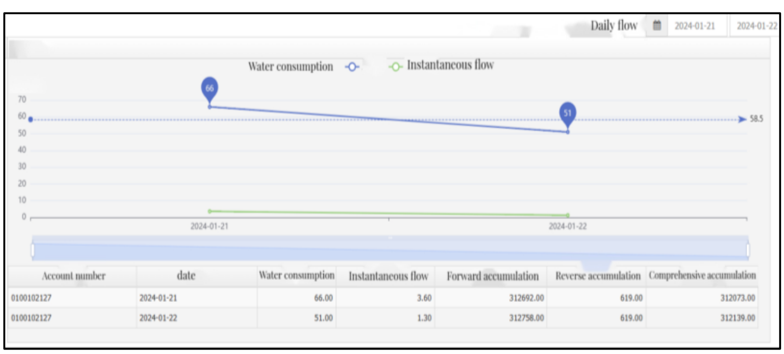


Fig. 4 Schematic diagram of smart water management platform (from the computer monitor)

## 3. Results and discussion

Based on the above analysis of the water-saving measures of the university, the following improvements can be made in terms of water-saving measures:

1). Although all water end devices in the school, such as faucets, toilets, and urinals, were already water-saving devices, not all water-saving devices are automatic, some of which are manual. Due to personal usage habits, some personnel might keep manual water-saving devices on for a long time when using them. It was recommended to gradually change manual water-saving devices to automatic water-saving devices (especially faucets) in the next stage; this would further improve the water-saving effect.

Table. 2 Campus Pipeline Maintenance Record (Partially) in 2021.

| **Serial number** | **Discovery (month, date)** | **Leak location and quantity** | **Repair (month, date)** |
|---|---|---|---|
| 1 | 2.23 | Orchid Student Apartment 30m$^3$/day | 2.27 |
| 2 | 3.15 | Orchid Student Apartment 30m$^3$/day | 3.18 |
| 3 | 4.22 | Business Faculty 130m$^3$/day | 4.25 |
| 4 | 5.25 | Plum Blossom Student Apartment 30m$^3$/day | 5.30 |
| 5 | 6.16 | Plum Blossom Student Apartment 40m$^3$/day | 6.20 |
| 6 | 7.15 | Plum Blossom Student Apartment 80m$^3$/day | 7.20 |
| 7 | 9.2 | Plum Blossom Student Apartment 60m$^3$/day | 9.6 |
| 8 | 10.15 | Plum Blossom Student Apartment 40m$^3$/day | 10.20 |
| 9 | 11.11 | Main water supply pipeline 200m$^3$/hour | 11.11 |
| 10 | 11.25 | Orchid Student Apartment 10m$^3$/day | 11.29 |

2). At present, the school had installed a Campus water inlet meter（M1) on the campus main water supply pipeline, water inlet sub meters (e.g., M2, M3) in public areas such as teaching buildings, Athletics Field (as shown in Figure 5.), and set up a remote smart water management platform, If the reading of the M2 was much higher than usual, it could quickly determine the presence of water leakage behind the M2. But if there was a significant difference in the reading between the M1 and the sum of all sub meters (i.e., M2+M3+...+Mn), although it could be determined that there was a leakage, it was not known where the leakage point was (i.e., the pipeline between M1 water meter and M2 water meter).

It was recommended to select several locations between the main and sub meters to install remote water meters for intermediate inspection, which would lock the leakage point more quickly and reduce the time for leak detection. The significance of this suggestion was significant, as we could see from the role of our own smart water management platform.

Before the establishment of a smart water management platform, campus managers only judged whether there was a water leakage phenomenon based on the difference between the readings of the only main water meter on the campus pipeline and the manual reading of the sub water meter inside the campus. Often, when making a water leakage judgment, it had been a long time since the leakage occurred, and the amount of water leakage could not be estimated. The maintenance time was also greatly prolonged, resulting in the loss of water resources; After building and putting into use the smart water management platform, 28 leaks were promptly discovered and repaired in 2021 alone.

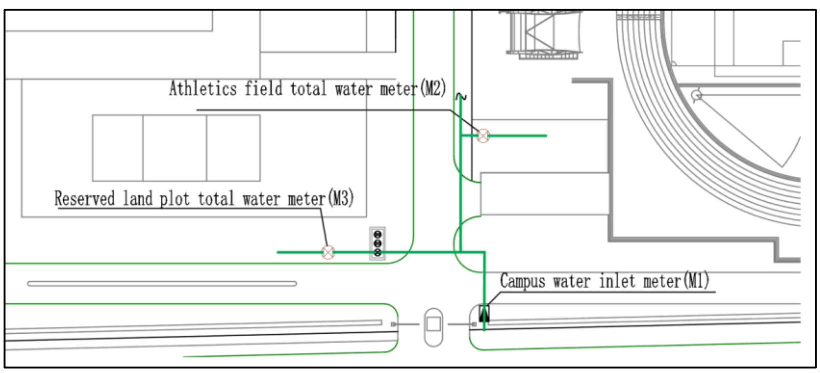


Fig. 5 Schematic diagram of campus outdoor water meter (partially).

**Assuming**: that without the installation of a smart water management platform, it took ten days to detect water leakage. At present, the water fee in the city was 4.5 RMB/ton; therefore, from Table 2. it could be estimated that the amount of water leakage for these ten times was: (30+30+130+30+40+80+60+40+10) $m^3$/day x 10 days + 200 $m^3$/hour x 24 hours x 10 days = 52,500m3. and, 52,500 $m^3$ x 4.5 RMB/ton = 236,250 RMB.

However, because a smart water management system had been installed, these wastes have been avoided. Similarly, installing a remote water meter on the pipeline between M1 and each Mn and incorporating it into the existing smart water management system would greatly shorten the time for water leakage detection, thus avoiding waste.

3). For dormitories with a hot water system with a hot water outlet speed greater than 15S, it was recommended to carry out pipeline renovation by extending the return water pipe section as much as possible to the end of the water supply, reducing the time for cold water release, and finding a reasonable T1, T2, T3 thermometer position, and repair damaged pipeline insulation facilities.

4). Water leakage reduction could be achieved through the repair of the rainwater recovery system, including the water level gauge, landscape pool, and miscellaneous water supply pipeline.

5). The laying of roads on the campus with permeable bricks and the establishment of more rooftop gardens should be gradually undertaken.

6). Miscellaneous water pipelines could be laid to the central lake of the campus, and the miscellaneous water source could be changed to the central lake of the campus.

7). The biological habits of various plants on campus could be familiarized with, and irrigation plans for miscellaneous water could be developed based on species, zones, and seasons. Humidity detectors in the soil could be set up to transmit data to the miscellaneous water irrigation system, ensuring irrigation only when necessary and maximizing the use of the miscellaneous water irrigation system.

**Assuming:** the usage time of the miscellaneous water system is 300 days in a year, the water resources and costs that would be saved in a year were 300day x 100 ton =30,000 ton, then, 30,000 ton x 4.5 RMB/ton = 135,000 RMB.

## 4. Conclusion

This study analyzed the water-saving measures and shortcomings implemented by a university in southern China, and the following conclusions could be drawn.

1). By replacing existing manual water-saving facilities with automatic water-saving facilities, water could be effectively saved.

2). Based on the existing leakage control achievements of smart water management, remote water meters between the main water supply meters and the sub water supply meters could quickly identify the leaking pipe section and perform rapid pipeline maintenance, thereby saving water, were recommended to install.

3). The reduction of cold water loss and acceleration of hot water discharge speed could be achieved by renovating the hot water system

4). The rainwater reuse system was repaired, and the construction of sponge cities was improved to effectively achieve the recycling and utilization of rainwater and miscellaneous water. Simultaneously, the reasonable use of miscellaneous water systems could save at least 30,000 tons of water consumption and 135,000 RMB of investment annually.

## 5. Limitations

This study was conducted as a case study; Therefore, certain shortages or restrictions will be as follows.

1) In order to renovate existing water-saving equipment, pipelines, and systems, it was necessary to comprehensively consider the investment cost, return period, and implementation time of the renovation (without affecting normal teaching activities).

2) The overall energy-saving and economic benefits generated by some water-saving renovations (such as replacing water-saving equipment, renovating hot water systems, and continuing the construction of sponge cities) still need to be further demonstrated through a period of practical application (at least one year) in actual use. The water-saving benefits will be influenced by factors such as user energy-saving awareness and management level.

## 6. Acknowledgements

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## *References*

[1] L. Liu, “Research on water resource security in China since the 21st century,” Inter. Political Studies, no. 2, pp. 136-159, 2023. (in Chinese).

[2] World Meteorological Organization, “State of Global Water Resources 2022 Report,” WMO-No. 1333, pp. 1-53, 2023.

[3] X. X. Sheng, “Global water resource: pressure continues to rise,” People's Daily Inter. Edition, September 26, pp. 17, 2023. (in Chinese).

[4] Ministry of Construction of the People’s Republic of China, “General code for design of building water supply and drainage and water saving,” 2021. (in Chinese).

[5] Ministry of Construction of the People’s Republic of China, “Domestic water saving devices,” 2002. (in Chinese).

[6] M. Ali, G. Munala, T. Muhoro, J. Shikuku, V. Nyakundi and A. Gremley, “Water Usage Patterns and Water Saving Devices in Households: A Case of Eastleigh, Nairobi,” J. Water Resource Protection, Vol. 12, pp. 303-315, 2020.

[7] K. Wong, Y. J. Zheng, Z. Zhang, Y. P. Tang, W. H. Song and X. M. Guo. “Investigation and Application of Water-Saving Monitoring Technology in Public Institutions,” Pearl River, Vol. 43, no. 6, pp. 45-52, 2022. (in Chinese, translated abstract).

[8] S. S. Anchan and H. C. Shiva Prasad, “Feasibility of roof top rainwater harvesting potential - A case study of South Indian University,” Cleaner Engineering and Technology, Vol. 4, pp. 100206, 2021.

[9] T. Liu, W. Z. Zhao, B. Ma and W. H. Zeng, "Research on the Construction of Rainwater Recycling and Utilization System in Universities, Taking Southern University of Science and Technology as an example," Industry-Specific Services, pp. 75-77, 2023. (in Chinese).

[10] K. Q. Zhang, H. S. Zhang, A. R. Ning, N. Wang, J. X. Li and L. B. Han, "Application and Development of Green Land Irrigation by Municipal Reclaimed Water at Home and Abroad," Journal of Agro-Environment Science, Vol. 24, pp. 384-388, 2005. (in Chinese, translated abstract).

[11] K. Q. Lu, "Application of Sponge City Concept in the Design of Water Supply and Drainage System for Building," Smart City, Vol. 277, pp. 129-132, 2023. (in Chinese, translated abstract).

[12] X. N. Li, J. Q. Li, X. Fang, Y. W. Gong and W. L. Wang, "Case Studies of the Sponge City Program in China," World Env. Water Resources Cong., pp. 295-308, 2016.

[13] H. Zheng, Z. H. Rao, L. F. Fang, D. Luo, "Design of Urban Intelligent Water Supply System Based on the Internet of Things," Sci. Tech. Square, Vol. 176, no. 7, pp. 185-188, 2016. (in Chinese, translated abstract).

[14] J. Pérez-Padillo, J. G. Morillo, J. Ramirez-Faz, M. T. Roldán and P. Montesinos, "Design and Implementation of a Pressure Monitoring System Based on IoT for Water Supply Networks," Sensors, Vol. 20, pp. 1-19, 2020.

[15] Q. S. Wang, D. X. Yang, X. X. Kong and K. Fang, "A leak detection system for water supply pipelines based on Internet of Things technology," Computing Tech. Information Dev., Vol. 8, no. 2, pp. 70-71, 2011. (in Chinese).

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Assoc. Prof. Boonruk Chipipop has held the position since 2000. He received his master in electrical engineering from King Mongkut's Institute of Technology Ladkrabang in 1997. His current research interests are fractional-order electrical network application and fractional-order control application applied to engineering management