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Water Management to Cope with the Effects of Climate Change *Best* ***practices in Water Management at Wageningen University & Research***

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Water Management to Cope with the Effects of Climate Change

Best practices in Water Management at Wageningen University & Research

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Abstract.
Wageningen University & Research studies the causes of heavy rainfall and droughts and is looking for solutions to these phenomena [1]. For example, green spaces in the urban environment ensure that water can be drained into the ground. Storage of water is also important, because not only the number of heavy rains is increasing, also there are longer periods of drought. On WUR Campus, these principles of coping with flooding and drought are applied. There is a sizeable area of green space which serves as a groundwater discharge area. The large ponds on campus are used to collect and store excess surface water. During droughts the ponds retain water on campus. In two campus buildings, rain is harvested for flushing toilets and watering inner gardens. The rainwater is harvested from rooftops and stored in underground water tanks. A natural garden was laid out in 1998, and four years ago a natural wetland garden was added to the campus.

The effects of climate change, such as droughts and rising sea water levels affect freshwater supplies, which makes efficient use of water increasingly important. WUR aims to reduce consumption of tap water every year, by increasing water use efficiency and switching to sources other than tap water.

Keywords: Water management, Green space, Water retention, Water recycling, Water consumption

1. Introduction

According to its mission 'To explore the potential of nature to improve the quality of life' [2], Wageningen University & Research (WUR) has sustainable development as a fundamental philosophy. Besides operationalising sustainable development in education and research, WUR also regards sustainability as an important principle in its operational management. Promoting and achieving sustainability is considered as a continuous and on-going process.

The amount of extreme rainfall and its severity is increasing in the Netherlands. There are more and more floods caused by heavy rain showers. Nevertheless, drought is probably the most urgent water-related problem that we are currently facing. Wageningen University & Research studies the causes of heavy rainfall and droughts and is looking for solutions to these phenomena [1]. For example, green spaces in the urban environment ensure that water can be drained into the ground.

On Wageningen Campus, these principles of coping with flooding and drought are applied. Storage of water is important. Not only the number of heavy rains is increasing, there are also longer periods of drought. In addition, due to climate change, freshwater supplies are under pressure. This prompts us to make an effort to reduce water consumption.

In section 2, we will describe the best practices for water retention and conservation on Wageningen Campus. Section 3 will give an insight in our best practices in the reduction of water consumption. In section 4, we will conclude with some remarks on the results so far and the challenges ahead.

2. The role for Wageningen Campus in water absorption and retention

Although the built-up area on Wageningen Campus has expanded rapidly in recent years, there is still a sizeable area of green space, which serves as a groundwater discharge area.

2.1. Water management system

The campus ponds and waterways with sluices are connected to the ecological water system of the city of Wageningen. See Figure 1 for an overview of the water system at the campus. During droughts water is retained in the ponds on campus. The large ponds on campus are used to collect and store excess surface water.

All buildings at Wageningen Campus have two separate sewage systems: for waste water and for rainwater. Rainwater is collected from the roofs of the buildings and is discharged into canals and the ponds on campus. Rainwater coming from roads and parking areas also flows towards the surface water on campus. At some places rainwater is collected in street vents to be transported to the surface water via pipes.

An example of in internal water system is the harvesting of rainwater in two campus buildings. Rainwater is stored in an underground water tank for flushing toilets and watering atria gardens. There is a new plan to build a new water storage tank which can be used to water plants on campus during periods of drought.

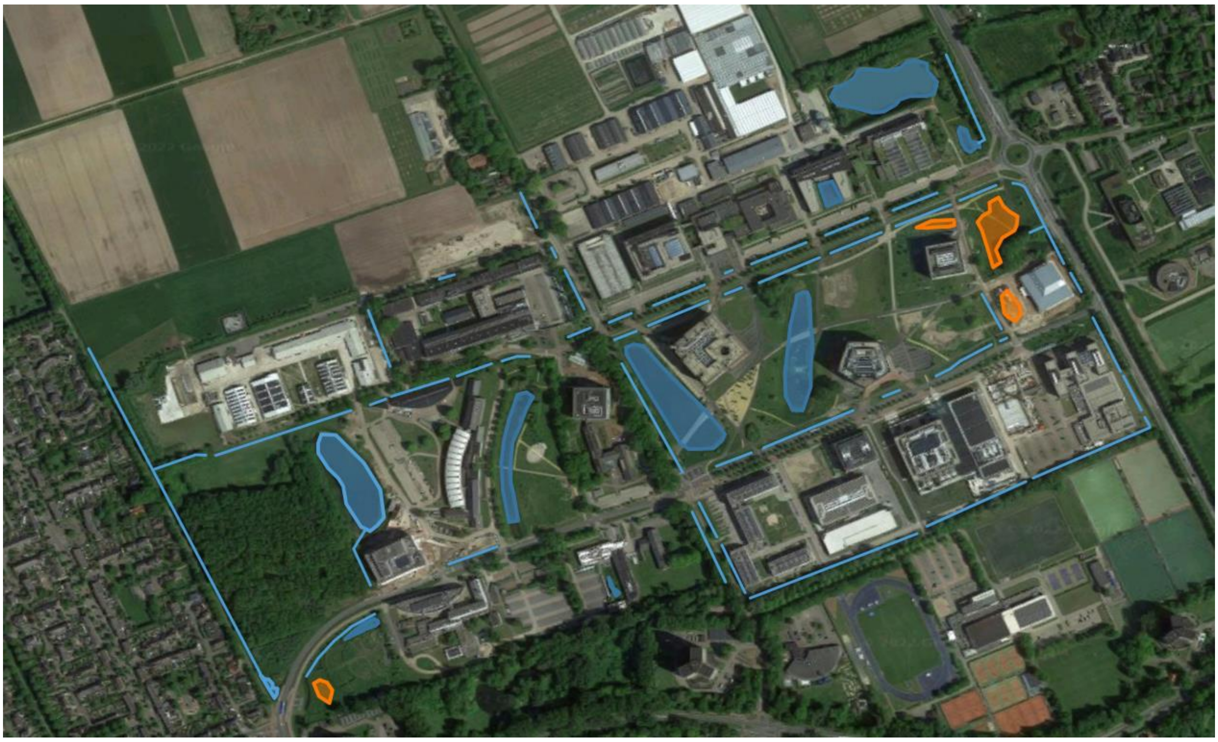

Figure 1. Ponds and waterways at Wageningen Campus (in blue), including two areas with recently created space for excess water (in orange) [3]

2.2 Water retention on campus

A natural garden with a large pond was laid out in 1998, with soils typically found in the surroundings of Wageningen. Diverse environments have emerged, such as those from the fluvial area and the sandy soils. Hundreds of plant species grow in the flowery meadow, including rare species such as orchids. The garden is visited by kingfishers and woodpeckers and there is a special shelter for bats. Ecologists from WUR took the initiative for this garden and are still actively involved in the maintenance strategy for the garden and other natural areas on campus. It is an example of how agricultural land or an industrial area can be returned to nature, with the right measures.

Figure 2. Seepage in the natural wetland garden

In 2016, a natural wetland garden was added to the campus (the orange area on the right in figure 1). Here, groundwater seeps to the surface, making the garden ‘wet’. The intention is to bring back some of the vegetation formerly found in the local area: blue grassland. The central feature is an old stream that has been newly dug up. Seepage and rainfall have brought about a marshy area around the stream, with species characteristic of the bluegrass vegetation. Various species from the older natural garden nearby have established themselves successfully. The stream has started to meander, it warms up rapidly, which makes it perfect for specific insects.

To store excess water, a new pond was created in 2021 on the west side of the campus (the orange spot on the left in figure 1). For a new education building on campus, loss of open water had to be compensated. The pond is connected to the ditches on the campus as a reservoir for excess water. The pond will probably lay dry for large parts of the year [4].

Figure 3. Example of the variety of the vegetation on campus

In addition to the natural gardens, there are various other types of vegetation on campus. There are areas with short mowed grass, flowery meadows, various trees, including a special collection of apple trees, shrubs, and beds with garden plants. The Field, an experimental garden, provides green space for informative and innovative projects related to the knowledge fields of Wageningen University & Research. All green areas, making up 69% of total campus surface, contribute to water absorption. Other benefits are biodiversity conservation, reduction of urban heat effect and other health and recreational benefits for students and employees.

3. Best practices in reduction of water consumption

The effects of climate change, such as droughts and rising sea water levels affect freshwater supplies. WUR aims to reduce water consumption continuously, with emphasis on the reduction of the consumption of tap water. The annual reduction in tap water consumption is stated as a target in the Environmental Multi-Year Plan 2020-2022: the goal is to reduce water consumption every year [5]. The strategy is to increase water-use efficiency and to use groundwater, greywater (recycling) or rainwater instead of tap water. In new buildings, water-saving devices are applied in cooling, toilets and showers.

An exemption is the use of tap water for drinking, which is encouraged, because of the benefits to health and the environment. However, use of tap water for drinking is a negligible amount of the total water use. Tap water in the Netherlands is of excellent quality and relatively cheap. The economic incentive to reduce the use of tap water is therefore weak, in the short term, the wish to reduce water consumption is almost exclusively prompted by environmental motives. In the long term, sufficient availability of water may play a role.

Water use is reduced in various ways by WUR. For example, in the buildings Gaia and Lumen , rainwater is used to limit tap water consumption. A large part of tap water is used for cooling for comfort in buildings or processes in laboratories [8]. These types of water consumption are a good starting point for further steps to reduce the use of tap water. The cooling system in laboratories at building Vitae, has been modified so less water is used. Cooling with tap water has been converted to cooling with grey water from water recovery. At various sites, groundwater is pumped up to limit the use of tap water.

Water use by WUR has decreased significantly over the years (see table 1 Trend in water use in 2005; 2018-2021), in spite of the growth of the organisation (see figure 4). Total water consumption decreased by 6% between 2020 en 2021. As a result of the corona pandemic, in 2020, tap water use decreased in office and educational buildings due to the lower occupancy rates caused by various lockdowns and hybrid working. This trend stabilized in 2021. The opening of a large education building in September 2021 was the main reason for the small increase in tap water use in 2021.

Table 1 Trend in water use in 2005; 2018-2021 [6]

Year	**2021**	**2020**	**2019**	**2018**	**2005**
Tap water (m^3)	135.523	134.820	156.084	167.062	234.503
Well water (m^3)	8.240	17.584	19.666	27.711	139.518
Performance compared to 2005	**2021**	**2020**	**2019**	**2018**	
Tap water (%)	-42%	-43%	-33%	-29%	
Well water (%)	-94%	-87%	-86%	-80%	

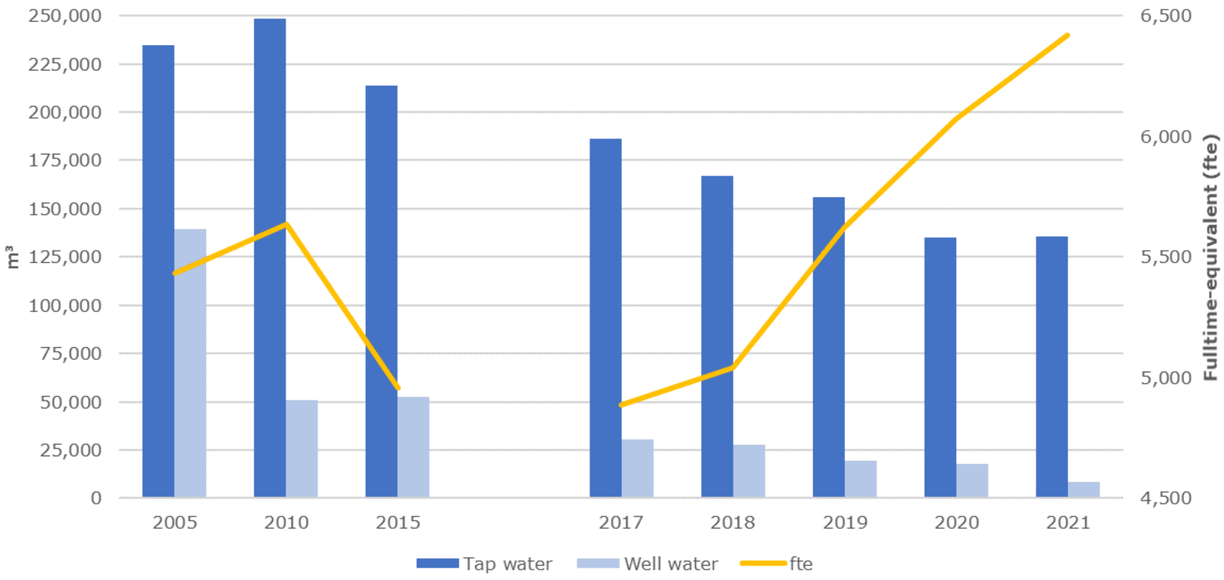

Figure 4. Figure Trend in water use in 2005, 2010, 2015 and 2017-2021

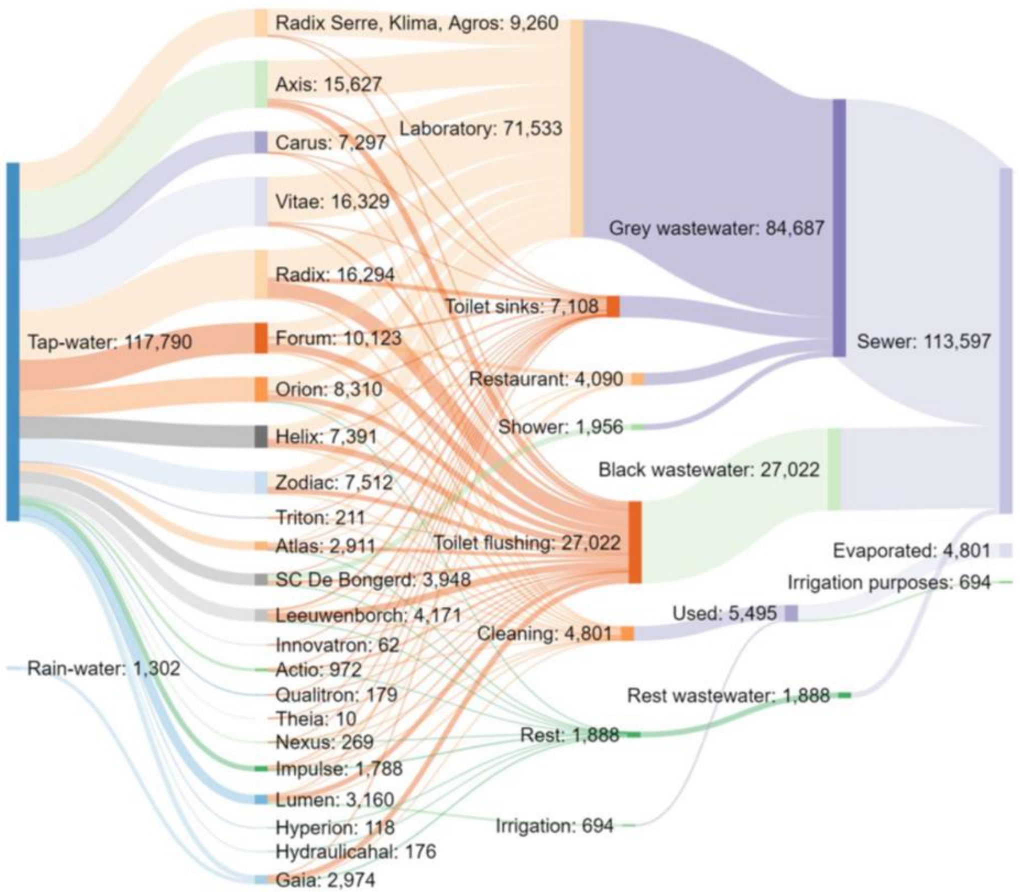

Figure 5. Water in and out flows at Wageningen Campus [7]

In 2019 a Material Flow Analysis (MFA) was carried out by a group of students, as an input for our policies on circularity. For the MFA water was identified as one of the material flows. Based on data from 2018 water inflow and outflows for Wageningen Campus were analysed. See figure 5 for the result of this analysis [7].

Laboratories account for over 60% of the water use and waste water. Treatment of waste water from laboratories, which may be chemically polluted, is more expensive than for other waste water. Procedures and systems are in place to prevent pollution with chemicals. Sewage water from laboratory buildings is regularly tested. In the Netherlands this is regulated in environmental permits.

Other water flows are used for toilet and urinals flushing (23%), for toilet sinks (6%), for restaurants (3%) and for cleaning purposes (4%). In 2019 we analysed water inflow and outflows for Wageningen campus, in m^3 (data 2017). This is a useful first step to identify flows that can be optimized. A further step would be to apply an Urban Harvest Approach (see section 4).

4. Concluding remarks: the challenges ahead

Meteorologists predict more extreme weather events in future. Heat waves, rain showers, hurricanes and periods of drought will probably become more frequent and more pronounced [8]. While writing this paper, there is plenty of evidence around the world to substantiate these expectations: heat waves are the new normal [9]. This stresses the urge for a sound water management strategy. We distinguish two elements: (1) the use of green and blue space for water absorption and retention and (2) the urgency to limit water consumption.

In research and education, WUR promotes the relevance of integral solutions in an interdisciplinary approach. For campus operations, WUR follows the same approach. The starting point for all strategies is to look for solutions that have multiple benefits: a campus with sufficient green and blue space absorbs water, helps to prevent flooding, is beneficial for biodiversity, and provides a pleasant, healthy, working space for employees and students.

Wageningen Campus serves as a groundwater discharge area. Space is needed for excess water. In spite of the growth of the number of buildings and urban infrastructure, the campus has still has a sizable amount of green space. Given future challenges, it is necessary to critically assess the role for the campus in climate adaptation. To assess whether the campus is climate proof, now and in the future, we are planning to do a stress test. Based on literature research, interviews and fieldwork, a quick scan will be made of the measures that could contribute to a climate adaptive campus. This will provide information on e.g. spatial typologies, system dynamics, including the natural system and user functions. These findings will be gathered in maps with explanatory stories and used as a baseline for possible future challenges. To take into account future trends, such as weather changes and the risks of pluvial flooding, a scenario of the Royal Netherlands Meteorological Institute (KNMI) will be used.

Given the low price of water in the Netherlands, the incentive to reduce water consumption stems from the wish to reduce our ecological footprint. Freshwater sources are increasingly under pressure, even in a water-rich country like the Netherlands. As freshwater is extremely important, every drop counts. In new buildings it is possible to apply water saving technologies, that should be standard procedure. For existing buildings and the campus as a whole, it is worthwhile to further explore the Urban Harvest Approach [10], for which the analysis of inflows and outflows [7] is a good starting point.

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