Water and the City. A Call for Climate Action through Water Saving Behaviors.

OSWALD JENEWEIN
University of Texas at Arlington

SEYYED AHMADREZA SHAHANGIAN
University of Tehran

MOHSEN HAJIBABAEI
University of Innsbruck

ROBERT SITZENFREI
University of Innsbruck

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Water – the petroleum of the 21st century. It is the well of life and after air, the most important element to survive. During the current stage of planetary crisis, water has become increasingly valuable to the city as climate models predict that both water scarcity and abundance will be putting urban ecosystems at risk in the decades to come. Given the systems scale of environmental problems humankind faces collectively, architecture must be understood as a systems component, integrated into natural, cultural, and built systems that leave the object scale behind and approach the city holistically. In developing solutions to climate change, the built environment plays a crucial role in actual design and understanding its users' behavior. This paper investigates water as a driver of spatial transformation and the circular-systemic role architecture and its users could play in decarbonizing the built environment through water saving strategies as a concrete call for climate action. It summarizes an interdisciplinary and cross-university research and teaching initiative conducted through a global campus framework between the University of Texas at Arlington (UT Arlington) and the University of Innsbruck (LFU Innsbruck). A seminar course offered at both institutions serves as a framework to bring faculty and students from climatically different zones together to investigate water pathways from alps to coast. Methodologically, the research study is built on the Theory of Planned Behavior (TPB). A detailed questionnaire has been developed and deployed with over 350 responses, aiming to understand water-saving behaviors among students at the respective campuses. Furthermore, students have been actively involved in drawing, visualizing, and diagramming the complex nature of water systems as they relate to the architecture of the city on various scales. The project concludes by emphasizing the significance of interdisciplinary and cross-university initiatives as ways to address climate change mitigation and adaptation. These initiatives establish connections between research and classroom activities, fostering a comprehensive approach to tackle environmental challenges.

WATER AS DRIVER OF SPATIAL TRANSFORMATION

For as long as humankind has conquered the earth, the relationship to water to sustain life and serve as a premise for settlement has been essential. As peoples settled down and villages became towns, cities, and mega-regions, the complex system of urban water got even more intertwined with natural, cultural, and built environments. Over the different stages of the Industrial Revolution, water systems established crucial networks of wells, pipes, and plants to enable growth, prosperity, and well-being for the members of the urban ecosystem. With the processes of urbanization and industrialization reshaping the settlement patterns in many parts of the world, both the demand and use of water have rapidly increased while the built environment has started to substantially contribute to environmental problems. While the context of architecture has always been both physical and non-physical, modern water networks also rely on both material and immaterial factors, including the behavior of consumers. These actors within the city are a fundamental factor in the production of space[1] and reach from humans to non-humans, from fauna and flora to the natural context that shapes everyday life. In times of planetary crises, natural, cultural, and built systems need to be integrated to tackle some of the most severe causes, drivers, and impacts of climate change to enable pathways to decarbonization.[2] As these systems merge, the role of the individual's behavior multiplied into collective action is a crucial component of developing more sustainable buildings, cities, and processes.[3] Moreover, urban water systems are considered as complex adaptive systems (CASs) that contain social, environmental, and technical components (e.g., consumers, supply resources, and infrastructures, respectively) interacting dynamically and continuously with each other.[4] Hence, water systems can be viewed as socio-technical systems, as they are interconnected with society and the environment which significantly affect their performance[5]. Within this relationship between social and technical, cultural and built, architecture and its users, the link between water infrastructure and user behavior is crucial across scales. With numerous climate change impacts manifesting through various forms of water, architecture needs to be thought of as a system as well.[6] The architectural object can no longer be viewed as isolated, but rather as a component of the urban ecosystem capable to both mitigate and adapt to climate change.

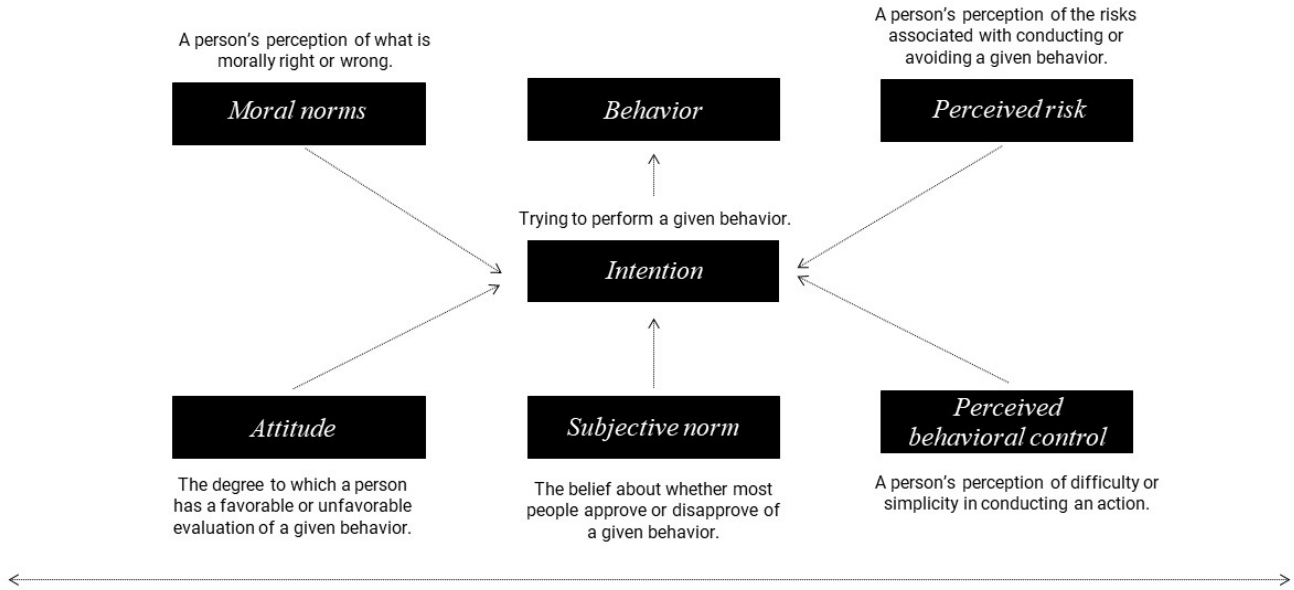

Figure 1. *Extended Theory of Planned Behavior applied in research study.* Oswald Jenewein, Mohsen Hajibabaei.

The primary goal of this paper is to emphasize the role of water as a driver of spatial transformation and the circular-systemic role architecture and its users could play in saving water. By doing so, both design and behavioral strategies to reduce water consumption, mitigate energy-intensive treatment processes, and avoiding unnecessary emissions are investigated. As a research-based teaching initative, this project aims to show how research informs teaching to allow students to become an integral component in data collection and visualization, and articulating a concrete call for climate action. Furthermore, this interdisciplinary and cross-university project is part of a global campus framework built upon an academic partnership program between UT Arlington in the United States and LFU Innsbruck in Austria. It utilizes two seminar courses as part of the respective bachelor of science degrees in architecture. Both the research project and course teachings are conducted by faculty and scholars of both institutions engaging students on both sides of the Atlantic.

LINKING RESEARCH & TEACHING FRAMEWORKS

This study integrates two seminar courses into a one-year research project on quantifying people's water-saving behaviors, linking architecture, engineering, and social sciences. This approach brings research methods, data collections, and interpretation of results into the classroom. From a psychological viewpoint, human behaviors are rooted in a complex process driven by psychological factors.[7] The aim of the research study was to explore key determinants and prerequisites affecting individuals' adoption of water-saving behaviors through the application of the Extended Theory of Planned Behavior (ETPB)[8,9] as the theoretical research framework (see Figure 1). For this purpose, a cross-sectional survey was conducted using a structured questionnaire as the research tool. Moreover, the study employed structural equation modeling as a powerful multivariate analytical tool in social and behavioral sciences to analyze data and examine the research hypotheses.[10] These methods of the research project were tied to the course content exposing students to interdisciplinary approaches. Students had the opportunity to learn about socio-technical methods, structuring a questionnaire, and how to analyze quantitative data.

The course design structures the semester topic into three main groups: (1) freshwater, (2) wastewater, and (3) stormwater. Within this framework, two distinct urban climate conditions aim to contextualize the respective investigations focusing on alpine versus coastal regions to follow the path of water from well to estuary. Each group consisted of eight students, split into four subgroups of two to conduct a transscalar investigation on the respective water system, one focusing on an ideal scenario, and the other on a disaster scenario (see Figure 2). These scenarios highlight the efficient and ideal operations of water systems and also failures and hazards as related to architecture and the city. The transscalar foci zoom from the (1) territorial to the (2) urban, (3) architectural, and ultimately into the (4) social scale.[11] On the territorial scale, students investigated the origins of fresh-, waste-, and stormwater and their pathways to the city, including the naturogenic and anthropogenic processes needed for each network. On the urban scale, the respective water lines within the city were investigated from a treatment plant to a household or vice versa. On the architectural scale, students explored water-use within a building, considering interactions between consumers and the respective networks as well as design strategies to conserve water. And lastly, on the social scale, the key determinants behind people's water-related behaviors, especially water-saving behaviors, were visualized based on pre-defined research variables of the Extended Theory of Planned Behavior, like attitude, subjective norm, perceived risk, etc. This transscalar approach aims to

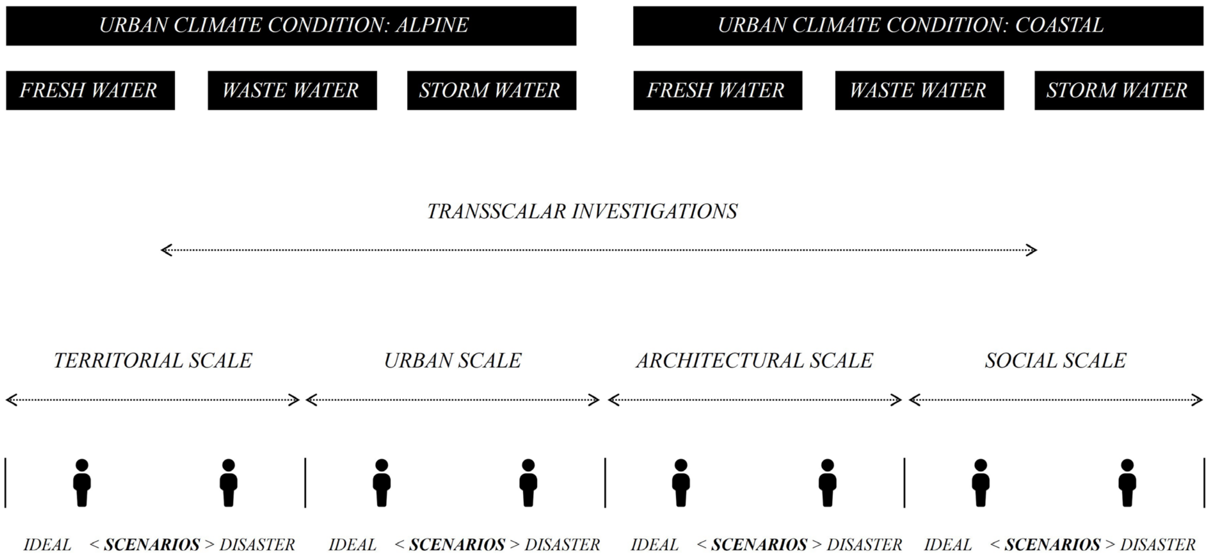

Figure 2. *Course overview (Raumgestaltung - Spatial Design)*. Oswald Jenewein, Mohsen Hajibabaei.

provide a holistic overview of both the discrete components and the macro-level systems of water within and around the city. Ultimately, each group had to answer four final questions through a series of diagrams to complete their assignments successfully (see Figure 3): (1) What are the discrete elements of urban water systems in different environmental conditions, (2) How are the elements of urban water networks forming a circular system and what are the challenges triggering disruptions, (3) What are the spatial effects and impacts of disruptions and disasters in water systems, and (4) What are the design strategies and behavioral actions to build resilient water systems enabling sustainable urban futures? This list of questions was also the structure for the final presentations when all drawings produced over the semester were exhibited.

INTEGRATING HUMAN & ARTIFICIAL INTELLIGENCE

Pedagogically, this course utilized a Socratic Pedagogical Model, based on argumentative dialogues between individuals and collective decision-making to stimulate critical thinking.[12] This teaching method emphasizes individual inquiry and collaborative problem-solving as essential components of the learning process through teamwork, visual and verbal communication. Various modes of interactive class activities were applied to enable a high level of collaboration. Especially in non-studio seminar courses with a substantial amount of theoretical rather than design

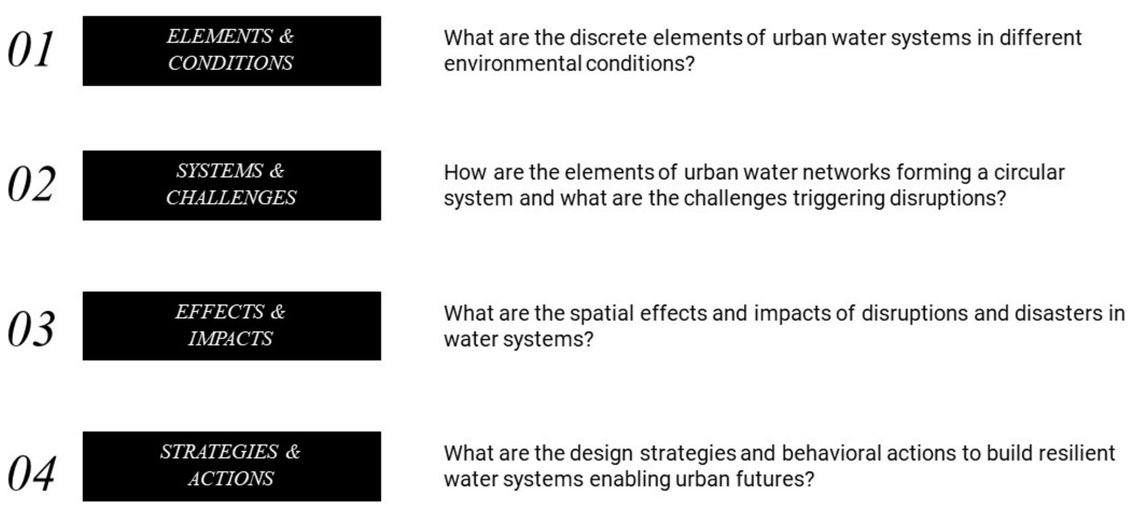

Figure 3. *Main questions for final assignment*. Oswald Jenewein, Mohsen Hajibabaei

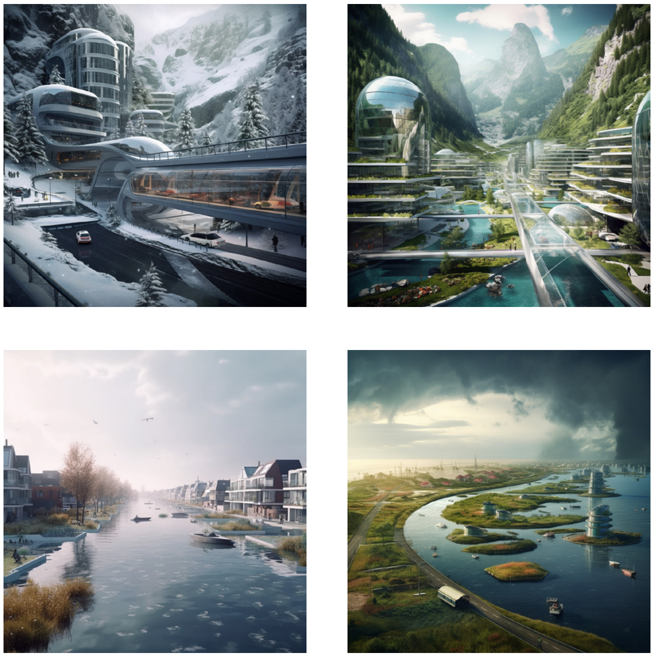

Figure 4. *AI-generated urban futures*. Arya Kamfiroozi, Oswald Jenewein.

content, engaging students in several ways is crucial. To tackle the course content, students used a combination of human and artificial intelligence (AI) to develop circular diagrams of the systems they investigated and to generate visual illustrations of various scenarios for sustainable urban futures in the respective climate condition they studied (see Figure 4). Utilizing these visualization tools ties the course content to the architectural language of drawing and diagramming rather than just reading and writing. AI image-generator tools were used alongside modeling and illustrating software to visualize concepts, strategies, and behaviors through multiple media (see Figures 5 and 6).

RESULTS & DISCUSSION: A CALL FOR CLIMATE ACTION IN ARCHITECTURAL EDUCATION

Within the age of climate crisis, the quest for an architectural response has been manifold. Architectural education has the responsibility to set the context for a growing generation of designers who will be, among other things, global citizens facing a planetary crisis. An open-minded and forward-thinking architectural generation, blurring the boundaries between the natural and the built, the analog and the digital, and the material and immaterial

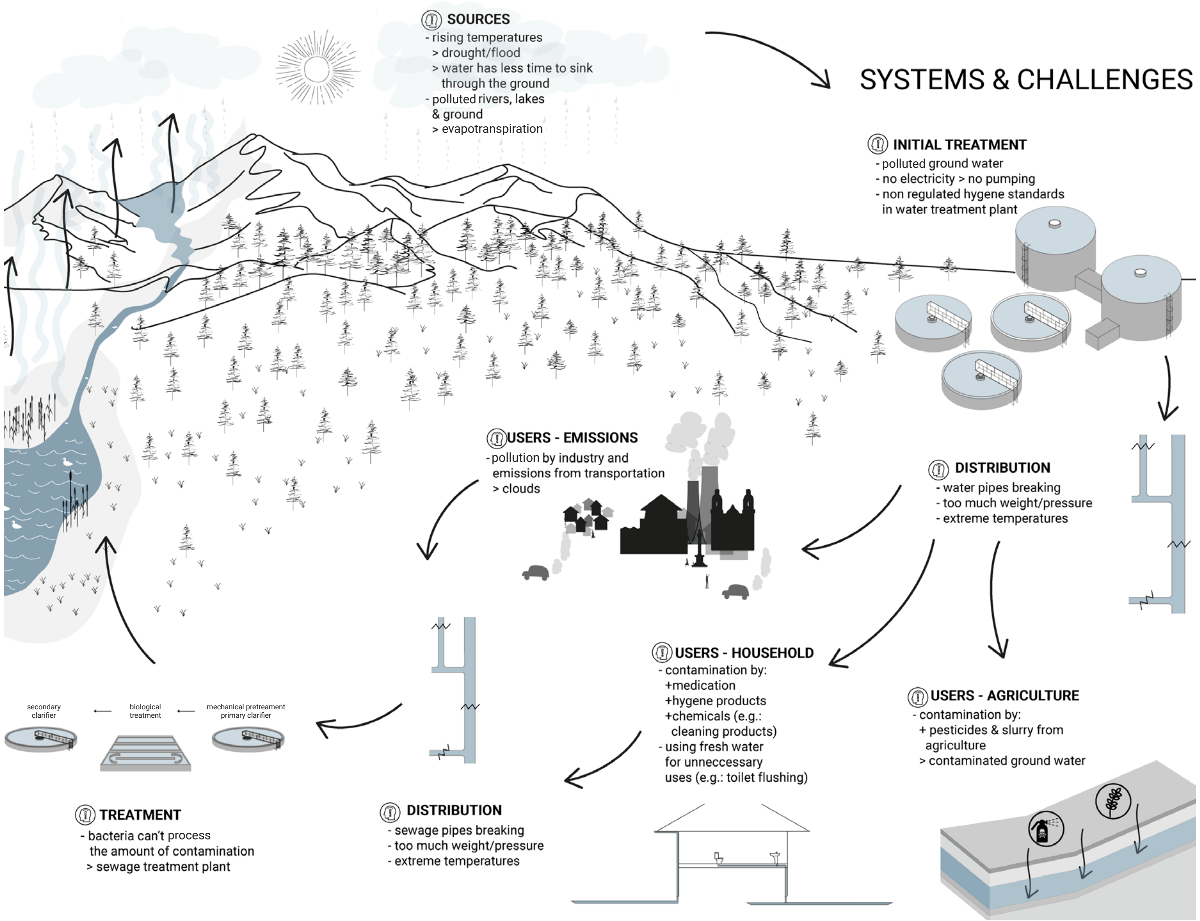

Figure 5. *Systems & Challenges*. Angela Ballheimer, Oswald Jenewein, Mohsen Hajibabaei.

qualities of space. This generation works interdisciplinary across different campuses and beyond, engaging a variety of stakeholders in academia, the profession, and the community. This study followed the pathways of water to, within, and from the city, articulating a concrete call for climate action on water-saving behaviors in a transscalar investigation working across disciplines and continents. Furthermore, this study combined research and teaching to visualize and understand water and the city based on quantified data on water-saving behaviors as a perceivable pathway for action in urban communities. The results of the research study have been presented internationally and are currently in the process of being published.[10] Therefore, students were able to link environmental topics to architecture, the city, and the human and non-human members of the urban ecosystem. This paper is a guide for faculty and scholars to plan interdisciplinary and cross-university projects, integrating teaching and research.

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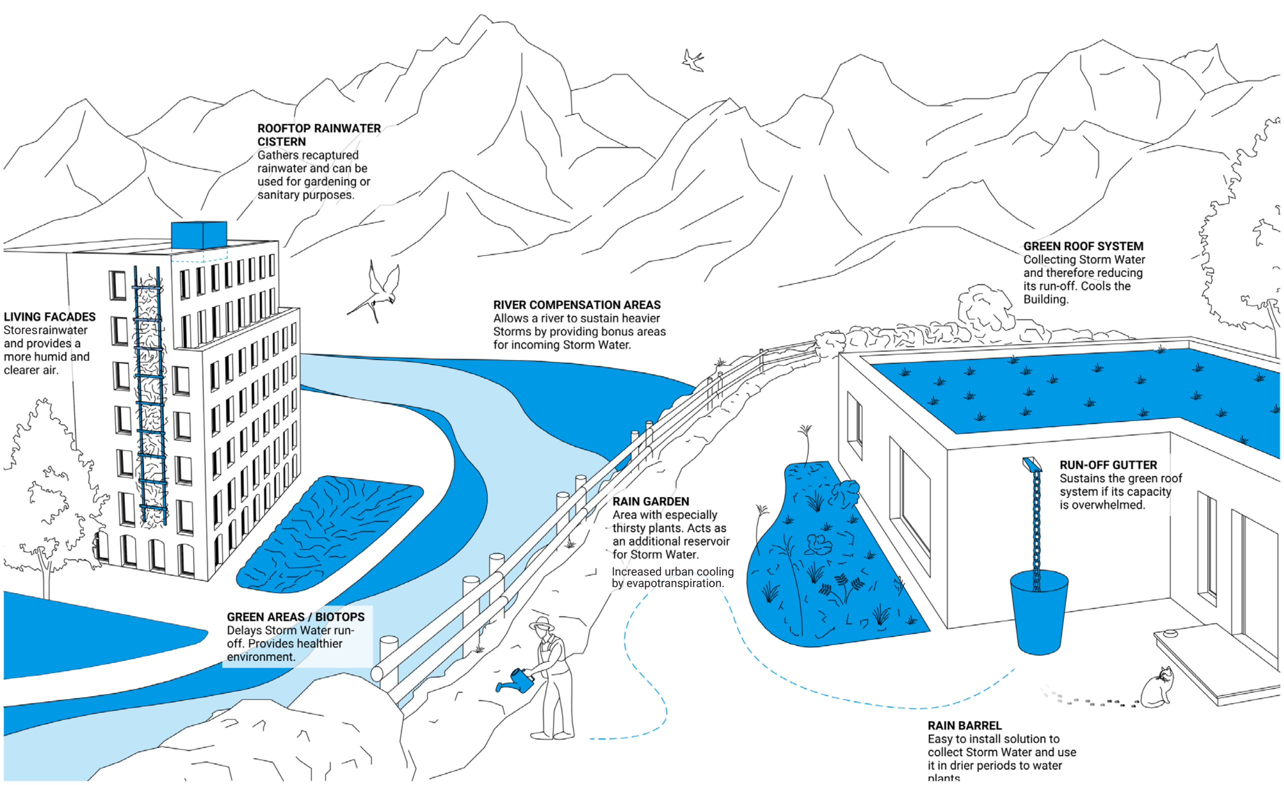

Figure 6. *Sustainable water management strategies in the Alps*. Martin Zott, Oswald Jenewein, Mohsen Hajibabaei.