# SMART WATER MANAGEMENT- INNOVATION WITHIN TRADITION

Matina Lazarová, Daniela Gažová

SPECTRA Centre of Excellence EU, Slovak University of Technology in Bratislava,
Vazozova 5, 812 43 Bratislava, Slovakia
martina.lazarova@stuba.sk, daniela.gazova@stuba.sk

**Abstract.** In global water arena, a consensus had been emerged that urban water management urgently calls for smart solutions in order to adapt to climate change. The ways our society is managing water resources are clearly in need of innovation and experimentation, but on the other hand call for reinstatement of traditional knowledge based on locally developed practices of water use. This paper describes a smart water system as a system that implements meaningful data and transforms it into actionable intelligence, but in the same time as a system build upon traditional knowledge. Transect coding is used as research method, to answer the question, how to smartly manage urban water systems at different scales and in different type of urbanized landscape.

**Keywords:** smart water management, water governance, transect coding, urbanized landscape

## 1 INTRODUCTION

In recent decades, the world has experienced unprecedented urban growth. According to the United Nations predictions, by 2050, seventy percent of the world population will be living in cities (United Nations, 2007). Europe is, for example, an increasingly urbanizing continent, where currently roughly three quarters of total EU population lives in cities, towns and suburbs (Eurostat, 2016). With such urban population grows, it is inevitable that the demand for water increases and pressure on finite water resources intensifies (PAI, 2011; Nilsson, 2006). Another starting point for this research is the assumption that global climate is changing, as stated in many scientific records (IPCC, 2007; COM, 2015; Friedlingstein, 2014) and, according to several publications has an increasing trend (Tin, 2008; Richardson, 2009; PBL, 2009; Sommerkorn and Hassol, 2009). The urban water cycle (incl. water supply, sewage, storm water, ground water, aquatic ecosystem – see Figure 1) is particularly at risk because the climate change mainly manifests itself through increase of extreme events (Howe et al. 2011, Fletcher, 2008). Consequently, the need to ensure that water can be managed sustainably, operated efficiently and maintained in high quality standard has been raised. Using big data techniques from all urban water components (Figure 1) have potential to enable the smart water management.

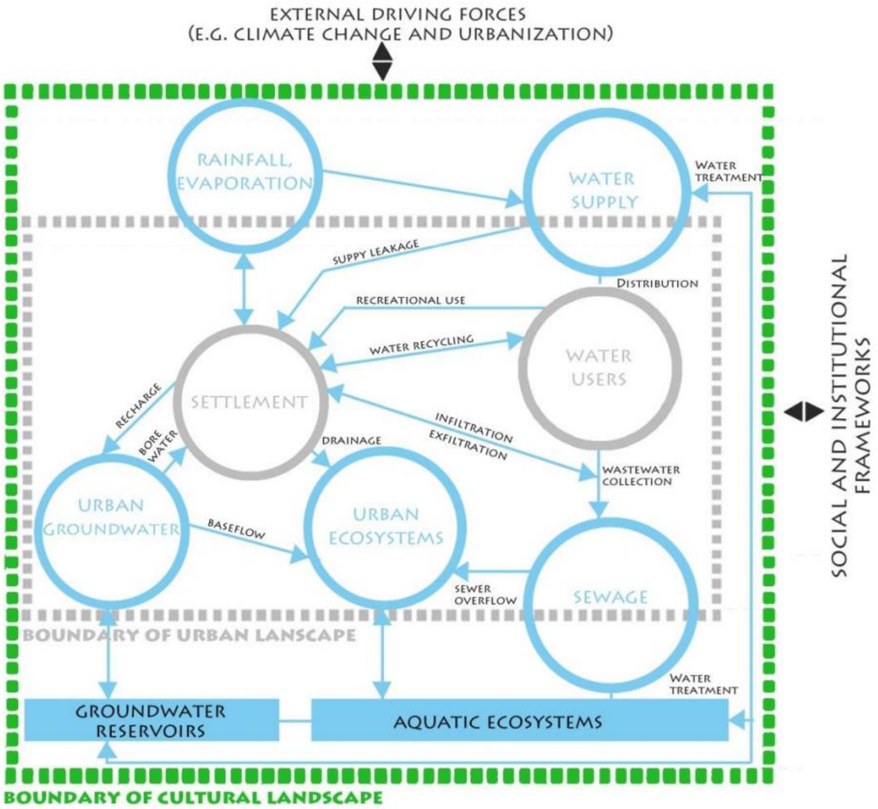


**Figure 1.** Urban water system interactions within urban landscape.
Resource: Author according (Fletcher, 2008)

The concept of the smart city has recently been introduced as "*a strategic device to links legacy systems with new communication chains in order to achieve a common goal of human welfare without compromising the sustainability of dependent ecosystems*" (ITU, 2015). Under water management perspective, the smart city concept highlights the importance of information and communication technologies in the last 20 years for enhancing water sustainability. The concept was originally developed by large IT companies that focus on analyzing "big data" using software-centric, top-down approach. Nevertheless, when it comes to the modernization of hundred-year-old water system, advanced software and networking capabilities are rarely broad enough to make self-adaptive systems. Therefore last couple of decades, there has been increasing interest in enhancing public in water sector, and thus allowing all possible stakeholders, both individuals and organizations, to participate in the decision process and to provide their locally based knowledge. Simply put, urban water systems need to be built upon time-tested practices and methods, which contribute to the variability of urban landscape patches (Sporrong, 1998). It is thanks to the local knowledge that many cultures were successful in sustaining their water resources for centuries. Therefore current water management needs to reclaim local knowledge of water management practices, thought the challenge of climate change, to present day.

Although extensive academic research is focused on new water technologies (Ingildsen and Olsson, 2016; Fishman, 2012; Lu, Ocampo-Raeder and Crow, 2014) a little attention has been given to the attributes of local knowledge and cultural values of historical water practices (Priscoli, 1998; Johnston, 2012; Tinoco, 2014; Ovink, 2015) within the concept of smart city. Through analysis of recent scientific articles and research programs the paper states that the literature on smart city concept does not describes smart water management as its sub-concept (Rockström, 2014). Thus, the first objective of the paper is, to develop adjusted framework of smart water management, moving beyond technical solutions and communication channels. In this paper the research presents an analysis of three discourses in water management. One is the established discourse "fighting the water" by water engineering approach, the other is the new discourse "the room for water" by water landscape approach and the third is "the living with water" by cultural approach. Second objective of the research is to design a cross-scale theoretical model that provides a proper insight on localizing smart water management solutions and governance options.

## 2 PROBLEM STATEMENT

Over the past decade, the concerns about extreme events and water scarcity have grown also within the EU (Rahaman, Varis, and Kajander, 2004). And why it is so? Simply put, water scarcity is often a by-product of climate change, current water management practice and unsustainable water policies. Moreover, current spatial planning practice does not enhance smart water management of urban landscape with an adaptive capacity to water related problems. Hence, cities do not easily adapt to the unpredictable events. As a result, the current academic debates are mostly talking about global water crisis that is heavy on problems and light on solutions. But what can be understood by the term - crisis? The word crisis, from its Greek roots krisis, refers to a time of great danger, difficulty or confusion when problems must be solved or important decisions must be made (Dictionary, Oxforf English. 2004.). Crisis signifies a time of decisive action, to a turning point, that may make things worse or better. A crisis also implies opportunity and not necessarily a disaster. Therefore, the paper defines the water crises as a highly needed wake up call to action and as a problem that have to be solved otherwise it will became irreversible (Priscoli, 1998).

## 3 SMART WATER MANAGEMENT

By assuming that the smart management of water is messy and contested concept, the research takes different schools of thoughts that describe how water management can be influenced by various underlying perspectives.

## A) PERSPECTIVE OF TECHNOLOGICAL INNOVATIONS

Until just a few decades ago, the materialization of great possibilities caused by industrial revolution brought the massive hydraulic development with large-scale, centralized water infrastructure systems for flood control, irrigation, water treatment, water distribution and sewage systems (known as "hard path"). On the one hand, there was the precondition that technologies generate wealth and development. Under this view, the ancient wish to transport water from where it is abundant to where it is scarce was satisfied and applied. In general, we know that water is both a key to socio-economic growth and quality of life (Priscoli, 1999). But expanding research about engineering approach raises more and more questions. Concerns have been raised that "one-type-fits-all" solutions are no effective and for the sake of water engineering, the urban landscape is losing its capacity to adapt to unexpected changes. Moreover technical solutions often do not solve the problem but just transfer it elsewhere. Critics of engineering approach to water management also place spotlights on the phenomenon that have been mostly seen within urban landscape, where small water cycles are often disturbed. As a consequence, the urban landscape has no adaptive capacity to deal with internal or external disturbances. On the one side, following century of blinding technicism, the current adaptation projects call for a new perspective that reintegrates water into spatial perception and water sensitive design, but also give a rise to new approaches that restore the ethics towards water and its cultural trails. However, in practice the right to decide is often in the hand of separate specialists (mostly engineers) that operate according to their own engineering techniques. Therefore the significant challenge of current water management is the implementation of adaptive water governance.

On the other side, according to UnWater agency (Water and Sustainable Development - From Vision to Action, 2015), the technology refers not only to physical equipment (as infrastructures and installations), but in a broader perspective, it also supports the innovations. Moreover, as stated by the United Nations, *" there are a number of on-going international initiatives aimed at accelerating the development, diffusion and transfer of appropriate, especially environmentally sound, water technologies"* (United Nations, 2014). It is important to realize, that although several technological achievements has been reached in the last decade, there is still a gap in this research field (Parodi, 2010). Environmental technology adoption enables societies to reduce their environmental impacts on water circulation. These green technical solutions however require a data with complex scope (data from public and private sector) and proper understanding of the context in which they are applied. Only the access to reliable information can help to overcome their failure. Furthermore, water systems evolve gradually and organically, that cannot be fully improved or "smartened up". They are almost never designed on "blank slate". It is not the aim of this paper to contribute to scientific debate regarding new water technologies based on environmental ground, but the point of the paper is to show how the progress in technological innovation research is needed for smart water management.

## B) LANDSCAPE PERSPECTIVE

In light of describing environmental concerns (global climate change, water pollution, landscape dewatering, etc.), industrialized world faces a massive decrease in biodiversity what is reflected to political debates, and new approaches (Tin, 2008; Richardson, 2009; PBL, 2009; Sommerkorn and Hassol, 2009). Taking into consideration the scope of water crises, ecologist and landscape architects warn that the current water management practices in urban landscape are no longer resilient. A review of the way in which the natural hydrological cycle and adaptive capacity of landscape are in the core, gives the first priority to the natural ecosystems. Under this perspective, ecosystems have similar rights to people, and should be treated with the same sensibility. Moreover, in the context of water management, the main idea of this approach is to support natural water movement in two stages. The first is renewable of small water cycles by promoting natural water processes as filtration, infiltration and self-purification. The second is preserving the large water cycles by resilient management of cultural landscape what means to sustain the regional diversity of cultural landscapes. Critics of this school of thought states that this approach has high space requirements and therefore cannot be applied in wide variety of context. For example in highly dense urban landscape are landscape-oriented solutions, as for example retention basins, rainwater gardens or irrigational belts, not possible. On the other side, there is a change to replace them by less effective but meaningful solutions as green roofs or green building walls etc. (Lazarová, 2015 Catalogue of hard and soft water solutions). Moreover, these "green" approaches, by contrast, have been relatively quick to address innovative onsite water solutions. However, most of these green projects focus exclusively on site-scale water management. Therefore, there is a great need to bring together the site-scale innovation being driven by the water landscape movement with the watershed management and integrated infrastructure planning being increasingly promoted and implemented by communities. Next spot on landscape-oriented approach is the concern, from the side of water engineers, that these "soft" solutions have small capacity to absorb the water. Another problematic issue is that in areas with high water table this approach could cause soil instability (as a result of waterlogging). The paper simplifies that especially in the urban landscape is highly needed to combine the landscape solutions with technical ones. Following Lazarová (2015), the key areas suitable for implementation of landscape oriented solutions with higher space requirements is the urban fringe. These zones are seen as edge–boundary between settlement and open landscape, where the urban density is allowing usage of the ecosystem-oriented solutions.

## C) CULTURAL PERSPECTIVE

What is important for the following perspective of cultural approach to water management is the fact that basic and collective perceptions about the world (such knowledge, attitudes, values, ethic etc.) are stored within every culture. These long-time preserved patterns influence our behavior and management practice (Johnston 2012). Under this view, the water culture refers to a certain stage of knowledge that is a result of mutual interactions between people and natural resources – as water. This knowledge is rooted locally in management practices, values, religions and ethics that have preserved in customary laws. Over the millennia people shaped their traditions in response to the distinct environment they inhabit. Along the way, the current water crises have been partially generated by techno-scientific cultures. Scientists who follow this cultural approach argue that current management models are still dominated by a paradigm of 'expertise'. In other words, mainly engineers, politicians, and water managers are deciding. Therefore the research calls for a broad-based cultural expertise that will take into account also the local knowledge and timed-tested solutions. It is necessary to realize that local knowledge, cultural stewardship and traditional practice developed by different communities preserve the cultural diversity. A better understanding of these cultural water beliefs and practices may lead to new concepts in understanding the water resilience - from flood management to water supply, sanitation and irrigation management. For this reason the challenge that the present-day society has to face is to match up to its ancestors: to give the adequate response to the moment in which that society is living (Cabrera, 2010).

### 3.1 DEFINING SMART WATER MANAGEMENT

The paper focuses on three discourses of smart water management that are deeply describes above. Firstly, engineering perspective has in fact too narrow focus on maintaining efficiency, constancy of the system, and predictable future. It aims to conserve what we have and to "fight the water". To do so, it offers progressive replacement of time-tested strategies by "one-type-fits-all" solutions. The invention of electrical pump was to water management what the elevator was to high-rise building or the car to transport. They all include paradigm shift with socio-economical, environmental and also spatial consequences. Many of the technical inventions are thus being critically reconsidered, but meanwhile there is still a need for new and next level technologies. Secondly, the landscape-oriented approach is strongly linked to ecosystems. This discourse is focused on building "the room for water". The third discourse is "the living with water" by traditional cultural approach based on implementation of local knowledge. More specifically, the following research questions were stated: **How to smartly manage water systems at different scales and in different type of urbanized landscape?**

The paper defines the smart water management concept as an overarching, interdisciplinary framework in which insights from different approaches (engineering, landscape-oriented and cultural) will fit and will result the development of water resilient city. The paper considers mentioned approaches to be complementary and both useful at different territories and different scales (Figure 2). The paper appoints that smart water management should implement relevant data and transforms it into systematic and intelligent decision making process at all levels (water governance). Conflict between these scales sometimes leads to conflicting management decisions, and subsequently an erosion of resilience.

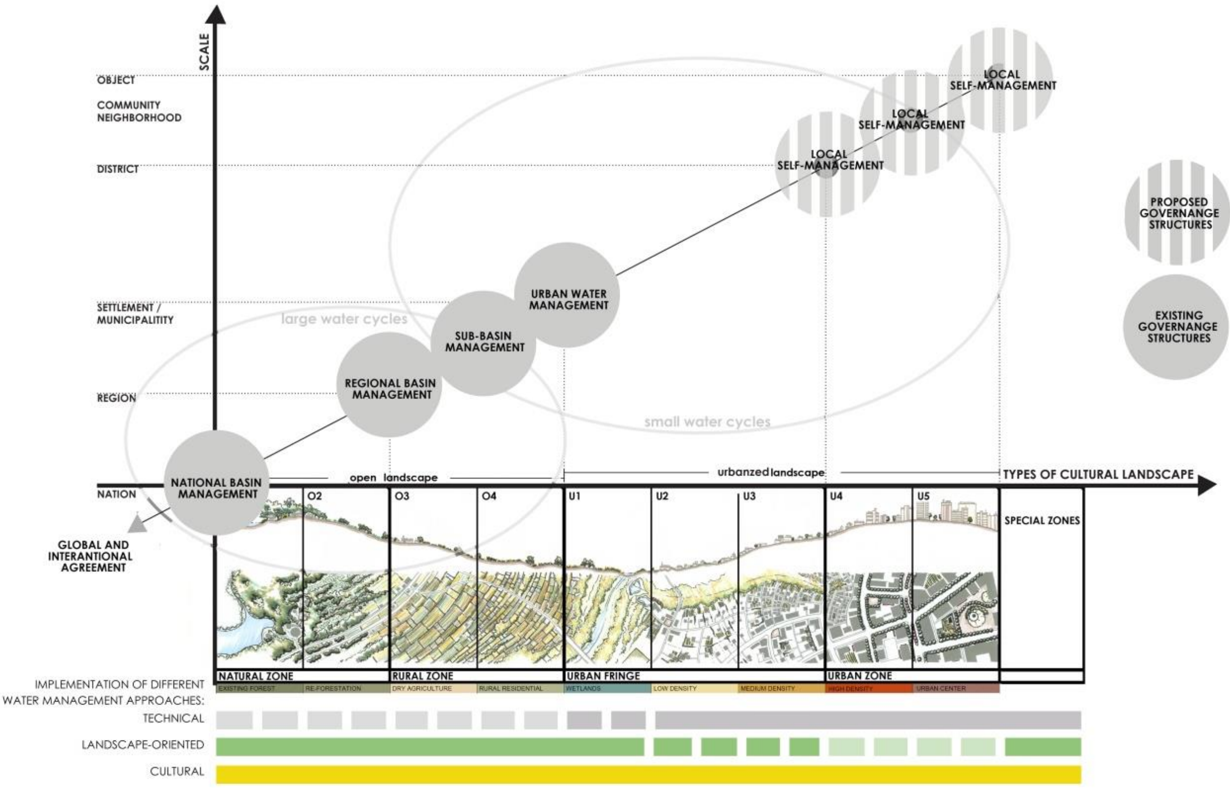


**Figure 2**. Model of smart water management as a cross-scale theoretical model that provides a proper insight on localizing water management solutions (model´s horizontal axis) and governance options (model´s nodes).
Resource: Author according AECOM (2010)

### 3.1.1 MODEL´S VERTICAL AXIS

Smart water management requires institutions at different scales (see Figure 2 – vertical axis). Model points it that water issues must be tackled at various levels. Smart and adaptive water governance requires a 'dance between levels'. Potential synergies between **Regional Basin Management** and **Local Self-Management** should be strengthened. Development and implementation of both of these management options have potential for:

- bringing a long-term, strategic focus covering large areas by using **Regional Basin Management** (The European Union's "top-down" governance arrangements e.g. Danube River Basin District with its sub-districts),
- translation of water management strategies — such as measures for more efficient water consumption — into **Local Self-Management action** (The

United States “bottom-up” approaches e.g. San Francisco Bay Area which has a long history of local control over water management)

### 3.1.2. MODEL´S HORIZONTAL AXIS

A transect method was used to illustrate different type of urbanized landscape from open space natural landscape to urban core. This code shows how future aspects of urbanization, such as buildings, infrastructure, land uses, and density should respond to water management (see Figure 2 - horizontal axis).

### 3.1.3. MODEL´S NODES

Scale captures construct´s nodes that are water governance options. These nodes can be qualitatively assessed by comparing the type of urbanized landscape (horizontal perspective) with a particular vertical scope. What is important to realize that smart scale mismatch is more likely to be the rule rather than the exception for most natural resource problems. For example, river systems cover a wide range of scales; from international (such as the Danube River basin) to multiple states (such Vah River sub-basin). Importantly, even though many of these managed ecosystems are defined by fixed geographical or spatial scales, they are always subject to influence by ecological processes operating across different scales including changing climate. Regional scale (Regional Basin Management) resource systems are managed at socially defined scales that may reflect history, culture, economics, politics or a myriad of other driving forces. More importantly, despite connectivity of the water source, problems that arise in water governance may range from local to basin wide. Rather than a one-size-fits-all approach to water governance, a mechanism to adapt response scale to the problem is needed. Both formal and informal institutional frameworks across existing governing institutions may be one aspect of that mechanism. The role of law in network formation should be to provide authority for exchange of information and collaboration or to step aside when it creates barriers to such exchange.

## 4 Conclusions

In Following an increasing series of unpredictable events (such as floods or droughts), more and more collective actions and initiatives calling for change are emerged. Furthermore, the current uncertainties pose special challenges, because planning processes based on uncertain predictions provides only an unclear approximation of the future and is a weak basis for smart water management. Therefore, the purpose of the research is not to find “best solution”, but outline the strategy to accept the unexpected as expected, and planning ahead to fight current environmental changes. To overcome the limitations of problem-solving methods, the paper requires assessing the root causes of water problems. In such approaches, indigenous and local communities are recognizes as invaluable partners that offer a wide variety of time-tested solutions. However, the local water problems are mostly managed and governed by regional, national or sometimes even international organizational mechanisms. As a result, water resources are brought under centralized, bureaucratic control, and the resilience of local water forms is strongly weakened (Johnston, 2012). Therefore, a better understanding of cultural values together with implementation of new and next level technologies is essential to catalyse change for smart water management regimes.

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