# KNOWLEDGE TRANSFER AND CAPACITY BUILDING: AN EXAMPLE FROM THE URBAN WATER SECTOR

Blal Adem Esmail* and Davide Geneletti*

* University of Trento, blal.ademesmail@unitn.it, davide.geneletti@unitn.it

## Abstract

Rural-to-urban migration and sustained natural population growth in Africa, if not properly addressed, may pose serious threat to ecosystems and human wellbeing, both locally and afar. Novel concepts and operative approaches are needed to better frame these challenges and support local decision-making processes, to promote sustainable development. Indeed, this is a key area in which the Academia can make a significant contribution, for example, exploring innovative concepts and developing related approaches to support decision-making processes at a local scale. This paper focuses on the urban water sector as an informative example, ultimately aiming to highlight key areas in which research can provide concrete and valuable assistance. More specifically, we introduce two innovative concepts, i.e. ecosystem services and boundary work; hence propose an operative approach to support the process of design and assessment of the impact of watershed investments. To illustrate real-life implementation of the approach in a data scarce context in sub-Saharan Africa, we consider as a case study soil erosion and water scarcity-related challenges affecting Asmara, a medium-sized city in Eritrea. Accordingly, we adopt urban water security and rural poverty alleviation as two illustrative objectives, within a ten-year planning horizon. The case study application resulted in spatially explicit outputs that inform decision-making processes. By timely addressing stakeholders' concerns of credibility, saliency, and legitimacy, the proposed approach is expected to facilitate negotiation of objectives, definition of scenarios, and assessment of alternative watershed investments. Above all, and beyond the urban water sector, the case study application helps highlighting key areas in which the academic work can make concrete contribution mainly in terms of knowledge transfer and capacity building.

## Keywords

Ecosystem services, urban water sector, boundary work

## Introduction

By 2030, Asia and Africa will host 90% of the additional 2.5 billion urban dwellers of the planet. In Africa alone, due to sustained natural population growth and rural-to-urban migration, the urban population is expected to more than double in the next two decades. This is an unprecedented opportunity for improving the living conditions of the people and, generally, for development in the continent. However, rapid urbanization and related land-use changes, if not properly addressed, can also pose serious threats to ecosystems and human wellbeing, both locally and afar. In worst-case scenarios, ungoverned urbanization has the potential to trigger conflict between communities, further exacerbate existing conditions of poverty and inequities, eventually, fueling ongoing migratory phenomena. Therefore, it is of utmost importance that current rapid urbanization in Africa is conceived within a framework of sustainable development, i.e. development that aims to meet human needs, while protecting life-supporting ecosystems. To this end, as part of international cooperation, academic endeavor has indeed a key role to play in exploring innovative concepts to frame the challenges, and in translating them into operative approaches to support policy, and decision-making at different levels.

Ecosystem service is a concept that prefigures a novel mode of conceiving the relationship between human and natural systems. This vision, promoted by institutions such as the United Nations and the European Community, is characterized by an unprecedented attention towards a proper assessment of the contribution to human well-being offered by ecosystems. An ecosystem, a portion of the biosphere, consists of living and non-living components that interact as complex dynamic systems, of which humans are an integral part (MA 2005), and ecosystem services are the direct and indirect contributions of ecosystems to human wellbeing (TEEB 2010).Increasingly, the concept of ecosystem services is used as knowledge base and as a tool to enhance decision-making relating to natural resource management, conservation planning, and water resources management (see for example Abson et al., 2014; de Groot et al., 2010; Geneletti, 2015; Maes et al., 2012).

Boundary work is a concept originally introduced to understand efforts to distinguish between “science” from “non-science” (Gieryn 1983). Recently, however, the concept has evolved, and been reframed to address an active management of the tension that arises at the interface between user and producers of knowledge (Cash et al. 2003, Clark et al. 2016). Boundary work is now defined as any effort put in place by any organization (or individual) that seeks to mediate between knowledge and action. Clark et al., (2016) well illustrates the theoretical background of boundary work, including the definition criteria (i.e. credibility, saliency, and legitimacy), attributes (i.e. participation, accountability, and boundary objects), and functions (i.e. communication, translation, and mediation) of boundary work that determine the likelihood of a successful transfer of knowledge to action. Most interestingly, the Cark and colleagues highlight two aspects that are crucial for identifying potential barriers to knowledge transfer, hence, for defining the most appropriate boundary work strategies: "what is knowledge used for" and "how the user perceive its source", respectively. In terms of use, knowledge can be used for enlightenment, decision-support or negotiation-support. In terms of source, users can perceive knowledge as their personal expertise, as coming from either a single community of expertise, or multiple communities of expertise. These are indeed crucial aspects to account for in order to facilitate transfer of knowledge into action. (For more on this see Adem Esmail et al., 2017; Adem Esmail and Geneletti, 2017).

Through a case study approach, we here explore how the above-mentioned concepts of ecosystem services and boundary work could be applied in an operational setting to inform decision-making in the urban water sector. Specifically, we develop and test an operational approach to support decision-making processes in a medium sized city in sub-Saharan Africa. We focus on the urban water sector mainly because it offers interesting insight into the challenges facing many cities in the Global South, including the need of substantial investments to build physical infrastructures and develop human capital, while restore degraded ecosystems. However, our ultimate aim is to highlight some aspects in which academic endeavor can make concrete contribution to international cooperation projects, mainly in terms of knowledge transfer and capacity building.

## The Case Study: Toker Watershed in Eritrea

Eritrea is a small country in Eastern Africa with a population less than six and half million. It is a prevalently rural country, almost 77 percent of the population, yet is currently undergoing rapid urbanization. During 1984-2010, its urban population had grown from 800.000 to 1.200.000, of which 37 percent took place in the capital, Asmara. With around 650 thousand inhabitants, Asmara accounts roughly for 10 percent of the total population in Eritrea. Since 1996, Eritrea got its independence in 1993; the country is divided in six administrative regions based on the main watersheds (See Figure 1). The case study area is located in the smallest and most densely inhabited region, the Central Region (i.e. "Zoba Maekel"), covering less than 1.2% of the total area yet hosting almost 17% of the total population. In this context, the focus was on the Toker watershed and its homonymous reservoir, built in the year 2000 for water supply to Asmara and its surrounding areas.

Soil erosion-, and water scarcity-related problems emerge among the most critical issues requiring urgent solutions in our case study. Soil erosion is caused by a long history of poor cultivation and overgrazing, unregulated wood and timber harvesting, lack of recycling of nutrients and poor management of organic matter, as well as rapid urbanization and demographic growth (Murtaza 1998, Tewolde and Cabral 2011). Water scarcity is mainly due persistent droughts associated with climate variability and change (Abraham et al. 2009; MoLWE 2012; IPCC 2014). Overtime, to face physical water scarcity, several reservoirs had been built to store surface water, during two wet seasons known as "kiremti" (June-September) and "asmera" (March-April). These reservoirs were the main sources of water for meeting urban and rural demands, including irrigation, livestock watering, domestic water supply, and other uses. Yet, soil erosion was rapidly decreasing their storage capacity, further compounding physical water scarcity in the region with economic water scarcity (Abraham et al. 2009).

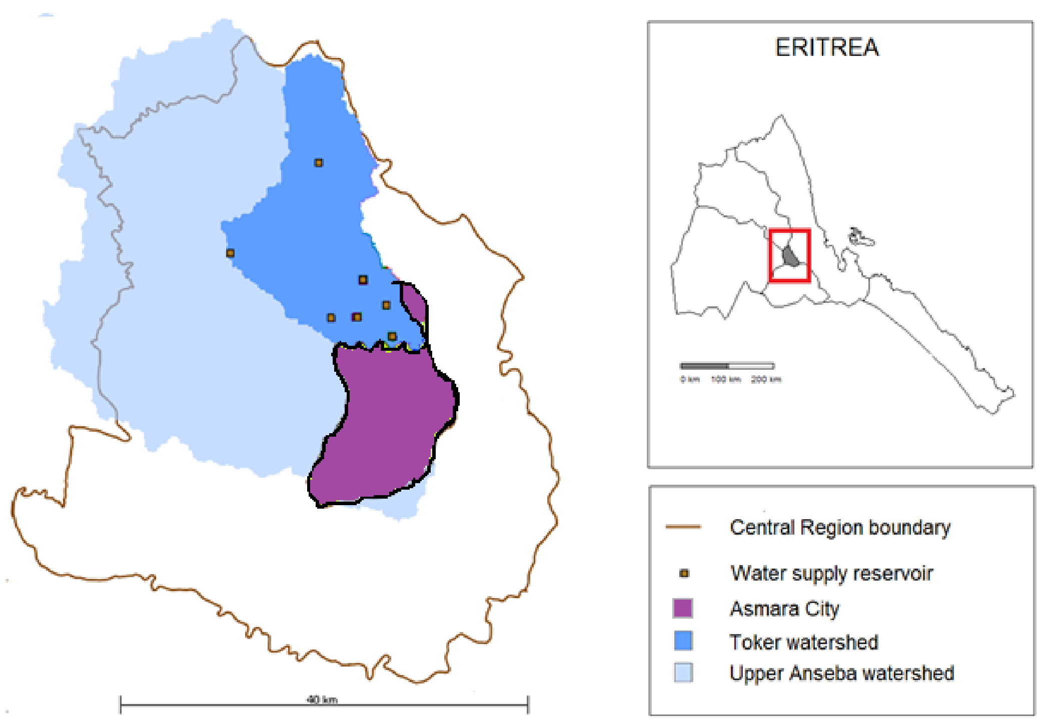


Figure 1: The Toker watershed, a sub-watershed of the Upper Anseba located in the Central Region, and the seven reservoirs that supply water to Asmara (right). The six administrative regions in Eritrea based on the main watersheds; the Central Region, the smallest and most densely inhabited in the country (left).

An illustrative example of how the ecosystem service concept can be useful for effectively framing the socio-ecological challenges in the case study is shown in Figure 2. Among others, it highlights the differentiated impacts different groups of people (Daw et al. 2011). On the one hand, soil erosion causes a rapid loss of storage capacity of reservoirs supplying the city of Asmara: according to Abraham et al (2009), the estimated average sediment yields in the region is of 856 t/Km$^2$, which corresponds to an annual storage capacity loss between 0.5 and 2 percent (Abraham et al. 2009). On the other, soil erosion affects livelihood of rural communities by resulting in lower yields: the Food and Agriculture Organization (Fao) has estimated that a rate of soil erosion of 1500 t/Km$^2$ per year could reduce yields by 0.2-0.4% a year for crops and 0.05-0.1% for livestock (Fao 1994, as cited in (Habtetsion and Tsighe 2007). As far as water scarcity is concerned, the total number of reservoirs in the Upper Anseba Watershed is 49, of which the 11 biggest ones (7 in the Toker watershed) supply water to Asmara, and 38 smaller reservoirs serve rural communities for drinking and irrigation purposes (Abraham et al. 2009). The aggregated storage capacity of the 49 reservoirs is 32 million cubic meters, of which 24.8 million m$^3$ (77.4%) is reserved for Asmara. Nevertheless, Abraham et al (2009) have estimated that, due to siltation, only 55-89% of that storage capacity is still available. Therefore, soil erosion and water scarcity hinder the city of Asmara from meeting its growing water demands at the same time seriously jeopardize the main sources of income of the rural communities, whose livelihood depends primarily on rainfed agriculture. For this reason, in this case study exercise, the two illustrative objectives considered for investment in the Toker watershed are Urban Water Security and Rural Poverty alleviation.

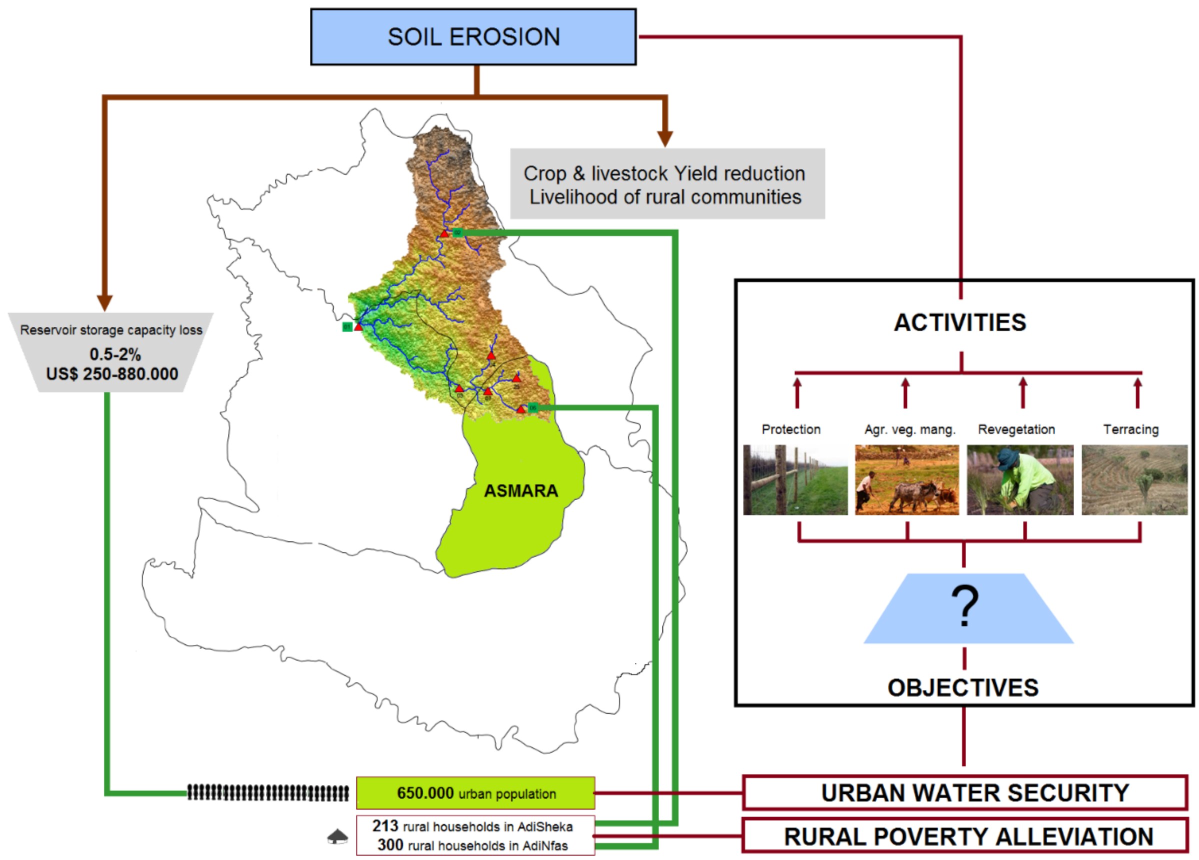


Figure 2: Framing of soil erosion-related challenges in the Toker watershed from an ecosystem services' perspective, highlight of (i) the spatial mismatch between areas of ecosystem services production and benefit, (ii) the different impacts on urban and rural beneficiaries, and (iii) the two illustrative watershed investment objectives in the case study application. Four types of activities covered by watershed investment, namely, protection, agricultural vegetation management, assisted revegetation and terracing.

**Watershed investment: A tool to promote sustainable urbanization**

Securing water is a pressing challenge facing many cities around the globe (Richter et al. 2013). Watershed investments to secure water for cities represent in fact a promising opportunity to effect large-scale transformative change that promotes human wellbeing while conserving ecosystems (McDonald and Shemie 2014; Guerry et al. 2015). According to an in-depth analysis of watersheds supplying five hundred cities worldwide, 25% of the cities would gain a positive return from watershed investments, with annual saving on water treatment costs exceeding US$ 890 million (McDonald and Shemie 2014). Watershed investments consist of governance and financial mechanisms that secure clean water for downstream users, mainly cities, and operate by engaging primarily upstream communities and nature conservation organizations (Higgins and Zimmerling 2013). They can target a wide range of activities, from changes in land use and alteration of vegetative covers, to education, and community outreach; and so enhance selected ecosystem services such as erosion control and nutrient retention, while conserving nature and biodiversity. Watershed investments may also have explicit social objectives such as poverty alleviation, which comprises both poverty reduction, and prevention (Daw et al. 2011). However, designing and assessing watershed investments can be challenging because it has to deal with barriers and boundary work concerns that are similar to the ones analyzed in the previous chapter. Thus, the need of adequate approaches for supporting their implementation, by duly addressing the concerns of different stakeholders. This includes taking into account both contextual (i.e. relatively stable) and contingent (i.e. relatively changeable) factors as well as the relative influence of stakeholders.

**An operational approach supporting the process of designing watershed investments**

Here, we propose an operational approach to support a process of design and assessment of the impact of watershed investments (see Figure 3). Based on consideration of the concepts of ecosystem service and boundary work, the approach is structured to facilitate negotiations among key water sector stakeholders, in terms of setting the agenda; defining investment scenarios; and assessing the performance of watershed investments and finally planning for a follow-up. On a more technical side, the approach covers data processing, tailoring spatially explicit ecosystem service models, hence their application to design a set of “investment portfolios”, generate future land use scenarios, and model impacts on selected ecosystem services. Interesting is the emphasis on the differing boundary work needs of different stakeholders (e.g. policy makers, farmers), at various stages of the process. Details on the approach and rationale behind it can be found in Adem Esmail and Geneletti, 2017.

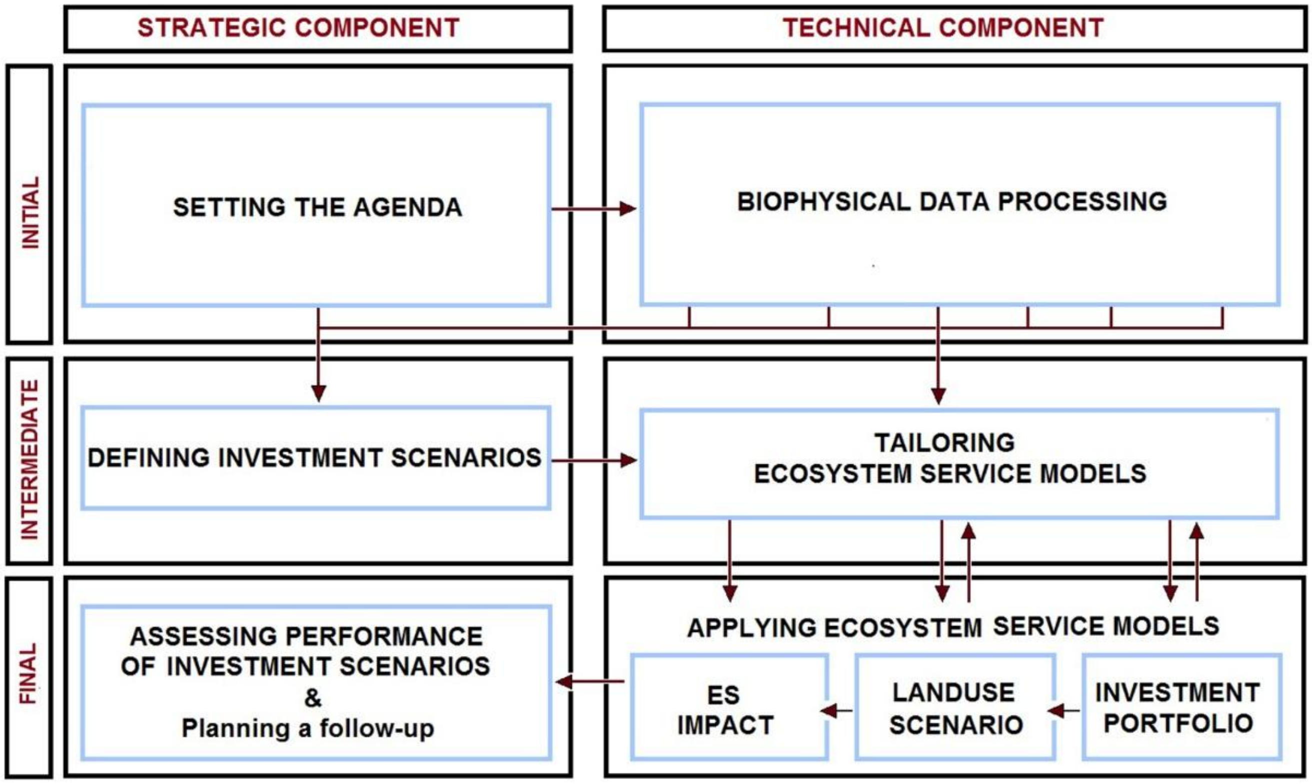


Figure 3: A process-based operative approach for designing and assessing impact of watershed investments, building on the concepts of ecosystem services and boundary works. (Source: Adem Esmail and Geneletti, 2017).

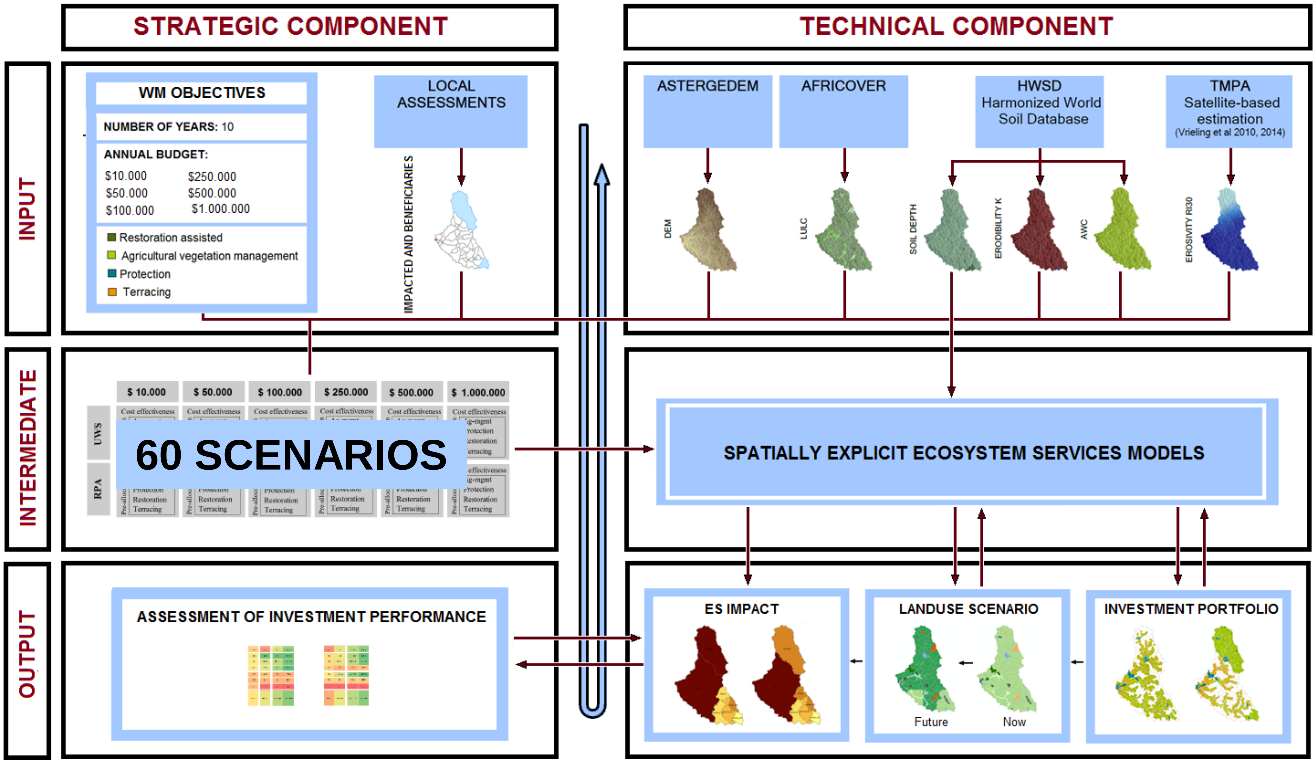


Figure 4: Application of the proposed approach to Toker watershed case study in Eritrea

A potential real-life implementation of the approach in a data scarce context in sub-Saharan Africa is shown in Figure 4. In particular, we consider soil erosion and water scarcity-related challenges affecting Asmara, and, accordingly, we adopt urban water security and rural poverty alleviation as two illustrative objectives, within a ten-year planning horizon. The application of the approach results in several spatially explicit outputs that support the design of watershed investment. A detailed description of the approach and the rationale behind is in Adem Esmail and Geneletti, 2017).

However, what is most interesting here is the fact that, by timely addressing stakeholders' concerns of credibility, saliency, and legitimacy, the proposed approach has good potential to facilitate negotiation of objectives, definition of scenarios, and assessment of alternative watershed investments, and thus to facilitate the transfer of knowledge into action. In fact the proposed approach highlights how each component of the process has differing needs of boundary work: for example, while the strategic component will have to ensure the saliency and legitimacy of the whole process, the technical component will be more concerned with the scientific credibility of the applied methods (e.g. type and quality of data, models etc.). Nevertheless, the overall success can only be one conceived as an emergent outcome of having first addressed each concern individually, within a general context of social learning.

Indeed, a key objective of boundary work is to have everyone "on board". This means, that the process ought to incorporate appropriate strategies of communication between stakeholders, translation of complex concepts into layperson language, and eventually mediation of conflicting interests. In other words, the necessary boundary functions of boundary work should be there. To this end, for example, the two components highlight different types of needs in terms of capacity building of the involved stakeholders. By way of example, Figure 5is an attempt to translate complex computation relating to spatially explicit ecosystem services modelling in order to make them accessible to non-experts, so that they came make a meaningful contribution to the process design of watershed investments as a whole.

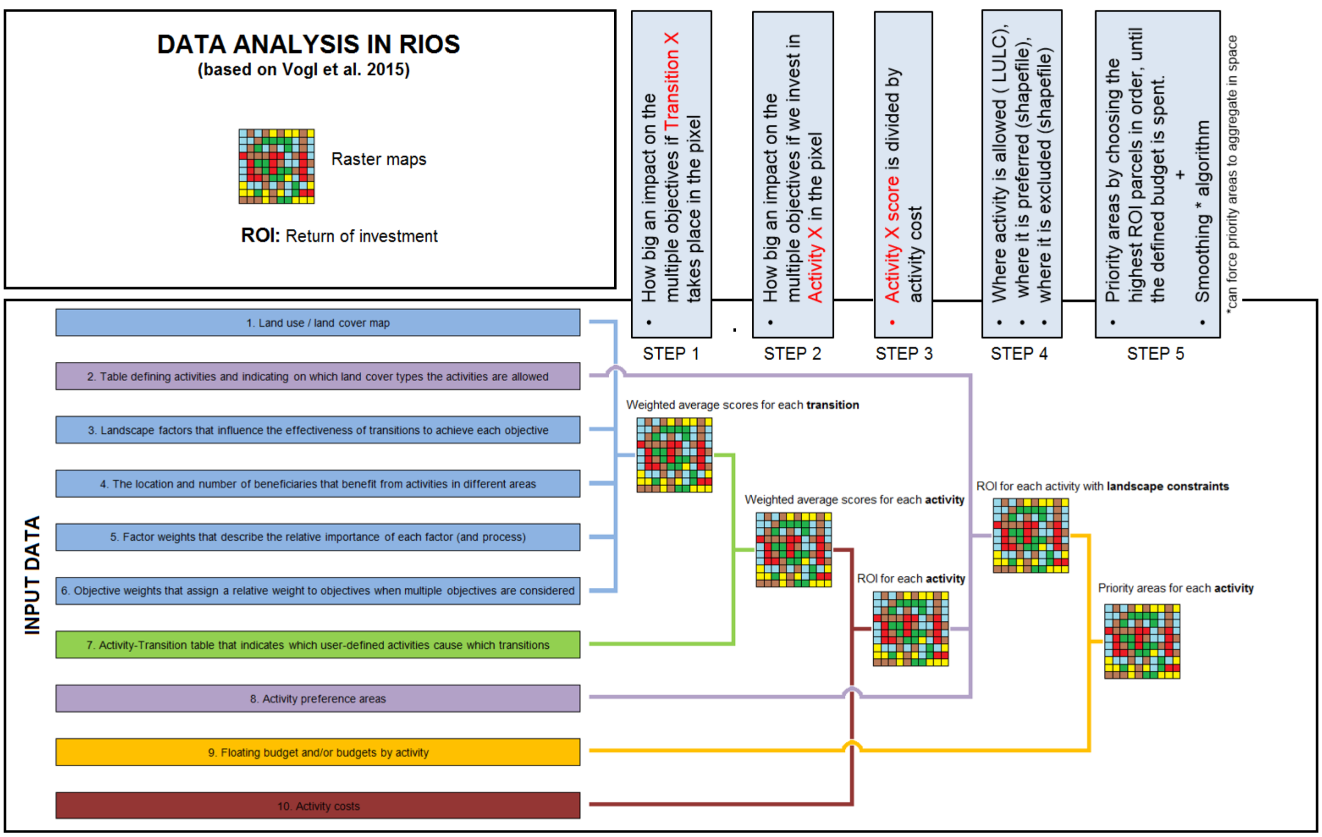


Figure 5: An example of translation of scientific concepts and methods to make them accessible to non-experts.

Finally, it is worth recalling that knowledge production is a social process, embedded in a specific socio-ecological context. A deep understanding of the contextual (relatively stable, e.g. regional identity) and contingent (relatively changeable, e.g. technological innovation) factors and the relative influence (i.e. power) of the main social actors is a prerequisite. In the case of the urban water sector, for example, water utilities are key players that represent important "gate-keepers for the introduction of any novelty in the sector" (Lieberherr and Truffer 2015). Recently, under the auspices of the World Bank, Kayaga et al., 2013 advanced a conceptualization of water utilities as learning organizations, and proposed a so-called "Water Utility Maturity Model" for assessing their institutional capacity. Beyond benchmarking purposes, the tool can be very useful identifying areas to be targeted by capacity building initiatives.

## Concluding remarks

Meeting the great environment and development challenges of our century requires heavily drawing from existing knowledge, among others. Such knowledge, however, needs to be tailored to each context of application, and this is largely the essence of the so-called "third mission" of the Italian Academia. Today, this mission is made less daunting by the emergence of a better theoretical understanding of what is needed to facilitate transfer of knowledge into action. In this paper, by way of example, we illustrated how research could make a substantial contribution to addressing specific socio-ecological challenges relating to rapid urbanization in an African city. More specifically, within a frame of adaptive management, the proposed approach support a process of design and assessment of watershed investments that aim at achieving multiple goals.

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**List of acronyms**

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| Fao | Food and Agriculture Organization |