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Research article

Defining the risk to water and natural capital in cities with risk component analysis tool (DAPSET): Case study Łódź

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ABSTRACT

Management of water resources poses a particular challenge in cities, due to the extensive degradation of the urban ecosystem and its limited self-regulatory capacity as compared to natural systems. Effective management requires an in-depth understanding of the sources (drivers) giving rise to such risk. This paper reports on a participatory identification of such factors driving the risk to urban water resources in the city of Łódź, Poland, carried out with the aim of testing a simple risk analysis tool (DAPSET - Drivers and Pressures - Strength Evaluation Tool), intended to yield the kind of complex data able to help assist city managers in decision-making processes. In the first part of the study, a number of selected public officials, students, researchers and NGO representatives were asked to rank the key socioeconomic drivers of water resources in the city. The four drivers identified as key (a low degree of environmental awareness among citizens, low law-enforcement efficiency, the city's low economic potential and land use changes) were then scrutinized in the second part of the study, which included a self-administered questionnaire designed to create a risk profile of drivers based on the DAPSET. Each of the four key drivers were analyzed with reference to eleven features. DAPSET revealed that all the key drivers share certain common features: they affect a large spatial scale, the damage they cause is persistent, and they involve either medium-high damage potential or probability of damage. The major differences between them stem from the dynamic features of the risk: societal attraction, invisibility, and availability of information. Analysis of the risk profiles so created against risk types pointed to the desirable directions of management and a need to go beyond standard actions.

1. Introduction

Water management in cities is particularly challenging to approach in a truly systemic way, due to circumstances of a spatial (extended built-up area), economic (high costs of infrastructure construction/removal, high prices of land) and social nature (expectations, system of values, appreciation). It is also highly heterogeneous across scales, due to resource availability, land legacies, financial resources, organizational and governing structure, and interactions between numerous stakeholders, internal and external to the system. In consequence, water management has developed into a complex (indeed, "wicked") problem (Head, 2010; Grafton, 2017), which cannot be solved within a single sector or domain (Rittel and Webber, 1973), and requires capacity building in terms of knowledge and information (Webber and Khademian, 2008).

One aspect of the indispensable knowledge, exchanged across the sectors, pertains to identifying the sources of the problem – "drivers" and "pressures" and the cycle of cause-effect interactions emerging from mitigation measures. Although there were several frameworks tackling this issue, including FDES – A Framework for the Development of Environmental Statistics (UNSD, 1984, 2017), PSR – Pressure-State-Response framework (OECD, 1998); or DSR – Driving forces-State-Response framework (Rapport and Friend, 1979) adopted by the Commission of Sustainable Development, none of them traced the full cycle of interactions. The two complete frameworks, synthetizing all the previous attempts, are the Press-Pulse Dynamics (PPD) model proposed by Long-Term Ecological Research Network (LTER) (Collins et al., 2011), and Drivers-Pressures-States-Impact-Response (DPSIR) model adopted by the European Environment Agency (2003). Although both these frameworks link factors coming from the social and economic domains with the biophysical conditions, and aim to facilitate decision-making process, the PPD model pays more attention to disaggregation of pressures and their influence on biophysical structures and ecological processes, while DPSIR strongly focuses on drivers and pressures, to some extent recognizing also the fact that the decision-making process can be a driver itself (Eduljee, 2000), influencing management

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outcomes. The latter is also closer to European decision-makers, who have to move forward from communication functions to practical uses, e.g. for elaboration of River Basin Management Plans. DPSIR implementations, however, reveal an important gap: the lack of appropriate tools to support adequate policy and management (Vannevel, 2018), which would bridge complex scientific findings with end-users needs (Fernandez et al., 2014).

There are a number of different approaches used in problem analysis, e.g. mind mapping or more advanced fuzzy cognitive mapping (Kontogianni et al., 2012; Henly-Shepard et al., 2015; Mourhir et al., 2016), and the strategic choice approach (Friend and Hickling, 2005), as well as complex frameworks such as the Future City Game (britishcouncil.org) and AtKisson's Indicators, Systems, Innovation, and Strategy (http://atkisson.com/tools/), which includes aspects of creativity and innovative thinking. There are also tools engaging the DPSIR framework into broader environmental assessment models, e.g. "Story And Simulation" (SAS) (Alcamo, 2001; Fernandez et al., 2014), which operate between storylines developed by participatory panels and model simulations. However, none of these methods allows one to concentrate on the roots of environmental risk, and to use both subjective and narrative assessments to derive standardized, comparable information able to streamline thinking towards a set of solutions. Meanwhile, in daily practice, which demands that environmental managers make fast decisions, based on understanding the nature of the problem (Mysiak et al., 2005) and needed vs available capital (human and economic), the ability to identify the best sequence of actions and to facilitate the multi-perspective exploration of problems (Shim et al., 2002) is a core of problem solving.

An elegant conceptual basis for disaggregation of the problem into components easier to understand and assess was provided by the German Advisory Council on Global Change (GACGC, 2000). Considering that the divergent preferences and states of development worldwide make environmental risks very heterogeneous, the Council proposed a categorization of the various risks into risk classes. This was intended to allow for the establishment of class-specific procedures and management rules that permit handling of risks in a way commensurate to the needs. Namely, the GACGC (2000) report defined six types of environmental risks: damocles, cyclops, pythia, pandora, cassandra and medusa, based on two aspects – the probability and damage potential of the phenomena. Further it identified three areas of their operation: normal – where problems are tamed, and standard procedures are sufficient, transition – when the standard procedures are not enough due to limited information (wicked problems), and prohibited – where it is well known that damage caused by drivers and pressures to the environment is high and irreversible, therefore this area should never be entered at any cost. Thus Damocles characterizes with high damage potential but low probability of damage, Cyclops is known only for its damage potential, Pythia incorporates factors with danger impending but none of characteristics is known, Pandora marks risks with unknown but most probably irreversible and ubiquitous effects, Cassandra groups factors of high damage probability and potential but foreseen for remote future, and finally Medusa consists of novel phenomena described by unconfirmed although alarming evidences.

The study presented herein builds upon that conceptual background, extends it, and transforms it into an easily applicable survey/tool for participatory characterization of risk emerging from drivers and pressures to water resources, in a typical Eastern European city under transition. It does not differentiate between drivers and pressures, bypassing to some extent the often-raised issue of the ambiguity of the terms themselves (Anastasopoulou et al., 2007; Oesterwind et al., 2016), which led to their partial substitution, e.g. in the Millennium Ecosystem Assessment (2005), with direct (e.g. habitat change, overexploitation) and indirect drivers (demographic, socio-political, economic, and cultural or religious). This simplifying approach was justified also by outcomes of the studies carried in socio-ecological platforms of LTER network, where dependently on the context, stakeholders tend to classify the same factors either as drivers or as pressures (Skogoey and Skov, 2007; Haberl et al., 2009).

The tool we sought to test was DAPSET - Drivers and Pressures - Strength Evaluation Tool (Ohl et al., 2007, 2009). The aim was to: 1) examine DAPSET's usefulness in terms of translation of the subjective and sectoral knowledge about drivers and pressures into a standardized system of their assessment and prioritization, 2) gather the knowledge about particular drivers and pressures to water resources in the City of Łódź, in terms of the risk they impose, and 3) identify how operational the whole concept is, in terms of defining short and long term actions to mitigate the risk related to selected drivers and pressures.

2. Study area

The city of Łódź is a typical representative of the heavily industrialized cities of Eastern Europe, in a transition stage towards new economic and management schemes (Kronenberg et al., 2017). The city originates from the nineteenth century, when it was established as a textile industry center, mostly due to abundant water resources (22 rivers). Rapid development of the city (with a population soaring from 4000 in 1830 to 500,000 in 1914) and its industry had a tremendous impact on the environment. High water demand, land acquisition, and waste release resulted in decline of river flows, severe pollution and in consequence the canalization of all the rivers (Liszewski, 2001; Kobojek, 2017). That situation persists to this very day, with one substantial change – increasing load of stormwater and modification of the water cycle as a result of urban sprawl. The disturbance of the water cycle superimposed by climate change (Podstawczyńska, 2010) has been leading to the deterioration of citizens' quality of life (Kupryś-Lipińska et al., 2014), the depreciation of city spaces, the decline of city greenery, and has lastly brought the issue of water management into political discourse.

However, the shrinking of the city's population (from over 1 million down to about 700,000) (Szukalski, 2012; Central Statistical Office, 2014a, 2014b) and the change of its economic profile from heavy industry to food processing, electronics, education and small scale textile manufacturing have lowered the impact on waters in terms of uptake and pollution (LDB CSO, 2017). Yet simultaneously, there are increasing environmental pressures related to political changes and social transformations, most importantly including the following: critically low and still decreasing median income of citizens (UMŁ, 2012), people's increasing aspirations and expectations in terms of life-style, increasing city indebtedness (from 33.5% to 54.6% of yearly income since 2004 (KRRIO, 2016, 2017)), and the aforementioned land conversion. Thereby, in the last decade the city has witnessed a substantial shift in drivers and pressures not followed by management schemes, and mostly unquantified (Kronenberg, 2015; Kronenberg et al., 2017).

3. Methods

The gathering of information about drivers and pressures was entirely based on a Learning Alliance platform. The members of the Learning Alliance were: citizens, NGOs, academics, the city authorities and companies involved in urban water management, planning and development in Łódź (Wagner et al., 2011). The first stage of the research sought to determine the four key drivers or pressures to water resources in Łódź based on the experiences and knowledge of decision-makers. To facilitate the process, the preselection of the factors was made in three steps. The initial list of drivers and pressures was taken from the original DAPSET tool (http://www2.ufz.de/alternet/, Supplementary Material). The list was completed after a Web of Science based literature review, carried out for the years 2007–2010 (compatible with DAPSET tool) and the compilation of words: *"urban", "water", "management", "challenges", "drivers", "pressures"* (Supplementary Material). The gray literature referring to the city was also included. The total list of drivers and pressures was discussed by researchers