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Analysing the cascades of uncertainty in flood defence projects: How "not knowing enough" is related to "knowing differently"

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ABSTRACT

It is increasingly recognized that uncertainty concerns more than statistical errors and incomplete information. Uncertainty becomes particularly important in decision-making when it influences the ability of the decision-makers to understand or solve a problem. While the literature on uncertainty and the way in which uncertainty in decision-making is conceptualized continue to evolve, the many uncertainties encountered in policy development and projects are still mostly represented as individual and separated issues. In this paper, we explore the relationship between fundamentally different uncertainties – which could be classified as unpredictability, incomplete knowledge or ambiguity – and show that uncertainties are not isolated. Based on two case studies of ecological engineering flood defence projects, we demonstrate that important ambiguities are directly related to unpredictability and incomplete knowledge in *cascades of interrelated uncertainties*. We argue that conceptualizing uncertainties as cascades provides new opportunities for coping with uncertainty. As the uncertainties throughout the cascade are interrelated, this suggests that coping with a particular uncertainty in the cascade will influence others related to it. Each uncertainty in a cascade is a potential node of intervention or facilitation. Thus, if a particular coping strategy fails or system conditions change, the cascades point at new directions for coping with the uncertainties encountered. Furthermore, the cascades can function as an instrument to bridge the gap between actors from science and policy, as it explicitly shows that uncertainties held relevant in different arenas are actually directly related.

1. Introduction

Sea level rise due to climate change is a major concern for many countries around the world and calls for adaptive management of coastal zone areas (Nicholls and Cazenave, 2010) and coastal ecosystems (Thom, 2000), in order to create social–ecological resilience to coastal disasters (Adger et al., 2005). Regarding coastal protection, ecological engineering – the design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both (Mitsch and Jørgensen, 2003) – seems to be a promising approach towards a sustainable future, as the feasibility of multiple alternative strategies is being researched (see Borsje et al., 2011 for a review). A prominent example of ecological engineering for coastal protection purposes is Building with Nature (BwN), a Dutch water management approach that aims to utilize natural dynamics (e.g., wind and currents) and natural materials (e.g., sediment and vegetation) for the realization of effective flood defences, while providing opportunities for nature development (De Vriend and Van Koningsveld, 2012). The basic philosophy of this approach is not exclusive for the Netherlands. The paradigm of water management is slowly changing from command-and-control approaches – hard engineering approaches emphasizing on reducing uncertainties and designing systems that can be predicted and controlled (Holling and Meffe, 1996) – towards more nature-inclusive approaches (Pahl-Wostl et al., 2011) and the use of natural dynamics in water management projects receives increasing international follow-up. Initiatives such as the Working with Nature approach of PIANC and the Engineering with Nature approach of the US Army Corps of Engineers are based on philosophies similar to the Building with Nature approach (Van Slobbe et al., 2013).

Although projects based on BwN design principles appear to foster the natural environment of the coastal zone in which they are implemented, a potential drawback of this ecological engineering concept is that the use of natural dynamics adds inherent uncertainty and ecological complexity to the designs created (Bergen et al., 2001). As weather conditions are

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unpredictable and our knowledge about natural system behaviour is incomplete, the outcomes of a BwN project are far from certain on beforehand. However, the uncertainties encountered during the development of a promising BwN project do not exclusively originate from shortcomings or inadequacies in the knowledge base. While the active involvement of local stakeholders is regarded as beneficial in order to come to better BwN solutions (De Vriend and Van Koningsveld, 2012), these stakeholders might have rather different or even conflicting views regarding the project. This can easily lead to ambiguity, a fundamentally different kind of uncertainty originating from the presence of too many possible interpretations of a situation (Weick, 1995). In previous research, Van den Hoek et al. (2012) found that ambiguity about the social implications of BwN projects is far more important for decision-making than uncertainty about the behaviour of the natural dynamics or the natural system, since these ambiguities could potentially hamper the project development process. Moreover, as time and spatial scales are not fixed in BwN projects, unanticipated developments can be expected at any moment. This suggests that, instead of a standard rigid uncertainty management plan, these dynamic projects require an uncertainty management approach that can be adapted to changing conditions.

While it is important to make a distinction between incomplete knowledge, unpredictability and ambiguity – because their nature is fundamentally different – they are not independent in the context of BwN projects (Van den Hoek et al., 2012). However, it is not fully clear what kind of relationship between different uncertainties exists. Even though the existence of such a relationship could be perceived as yet another complexity in an already complex field, it might also provide major benefits in the form of unexplored approaches to cope with interrelated uncertainties in water management projects. This is important because, in multi-actor decision-making processes, uncertainties that have a different nature normally require fundamentally different coping strategies (Walker et al., 2003; Van der Keur et al., 2008; Kwakkel et al., 2010; Brugnach et al., 2011). Common responses to cope with incomplete knowledge and unpredictability in decision-making are to acquire more information, e.g., by performing additional research and consulting experts, or to increase the top-down control over the process, e.g., by limiting the number of participants and centralizing the decision authority (Koppenjan and Klijn, 2004), but such strategies are unfit to solve a situation of ambiguity (Brugnach et al., 2011). However, if different uncertainties are interrelated, this situation might change since it suggests that coping with a particular uncertainty will influence those with which it is related. For instance, successfully coping with a particular situation of incomplete knowledge might influence an ambiguity with which it is related in a positive way.

In this paper, our objective is to explore the relationship between different uncertainties. To this end, we combine the relational approach to uncertainty of Brugnach et al. (2008) with theory on cascades of uncertainty from climate change literature in order to elucidate new ways for coping with uncertainty. We aim to illustrate that those managing a project can benefit from the relationship between different uncertainties in order to adaptively manage uncertainty in initiatives such as BwN projects. Therefore, we study two BwN pilot projects (namely, the Safety Buffer Oyster Dam and the Sand Engine case), identify several *cascades of interrelated uncertainties* and address how these cascades were managed.

This paper is structured as follows. First, we discuss the relational approach to uncertainty that we adopt and address our method for describing relations between different uncertainties (Sections 2 and 3). Second, we discuss our two case study projects, identify the most important uncertainties for each project and the uncertainties related to them, and describe how the project team managed these uncertainties during project development (Sections 4 and 5). Third, we discuss the characteristics of the cascades of interrelated uncertainties and the implications of our findings for uncertainty management (Section 6). In the last section, we present our main conclusions.

2. Theoretical concepts

2.1. Adopting a relational approach to uncertainty

We adopt the approach to uncertainty of Brugnach et al. (2008) that addresses the topic from a relational point of view, paying particular attention to how an actor (e.g., a decision-maker) relates to a problem situation he or she is to decide upon. Much can be uncertain regarding the characteristics of this problem, its possible solutions and the knowledge available about the system under consideration. However, this uncertainty has no particular significance or meaning for an actor involved in the decision-making process, until it leads to a situation in which it influences his or her ability to determine what the problem is or which action path to pursue. For example, in river basin management, uncertainty about the runoff of the river basin in itself may not be of importance for a decision-maker. However, when this decision-maker has to decide about raising the dikes along the river, he or she may become concerned about the characteristics of the river basin. As data about runoff is essential knowledge to come to an informed decision concerning the dikes, the uncertainty about this characteristic of the river basin now becomes significant and acquires meaning for the decision-maker. In short, an uncertainty has no meaning in itself, but acquires meaning when the decision-maker establishes a knowledge relationship with the system he or she aims to manage. Thus, uncertainty refers to *the situation in which there is not a unique and complete understanding of the system to be managed.*

According to the adopted conceptualization, uncertainty can originate from incomplete knowledge, unpredictability or ambiguity (Fig. 1). Incomplete knowledge and unpredictability are recognized by many authors in the literature (see Van Asselt, 2000

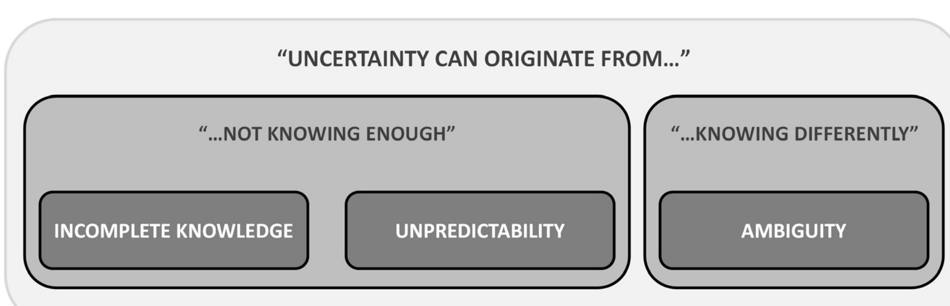

Fig. 1. Schematization of the adopted uncertainty conceptualization.