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Adaptation Pathways and Real Options Analysis: An approach to deep uncertainty in climate change adaptation policies

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Abstract

Governments face the daunting task of developing policies and making investment decisions for climate change adaptation in an environment that consist of complex, interlinked systems with manifold uncertainties. Instead of responding to surprises and making decisions on ad hoc basis, a structured approach to deal with complex systems and uncertainties can provide indispensable support for policy making. This contribution proposes a structured approach for designing climate adaptation policies based on the concepts of Adaptation Pathways, Adaptive Policy Making, and Real Options Analysis. Such an approach results in incorporation of flexibility that allows change over time in response to how the future unfolds, what is learned about the system, and changes in societal preferences. The approach is illustrated by looking at drainage policies and measures to address flooding in Singapore.

Keywords: Uncertainty; Climate change adaptation; Adaptation Pathways; Real Options Analysis; Adaptive Policy Making; Water policy

1. Introduction

Policymakers face growing complexity in committing to long-term investment decisions for large-scale engineering and infrastructural systems. Designers and architects of such systems need to consider technical, socioeconomic and political uncertainties, ambiguities, intricacies, and processes in the context of long-term strategic deployment and operations of these systems. Under such backdrop water management is nowadays challenged by climate-associated changes such as sea level rise and increased spatio-temporal variability of precipitation, as well as by pressures due to population growth and rapid urbanisation. Dealing with these highly uncertain changes requires different and new approaches to policy making and planning to develop robust systems.

Several studies have estimated the global costs of climate change adaptation (e.g. De Bruin, Dellink, & Agrawala, 2009; Stern, 2007; UNFCCC, 2007; World Bank, 2010). The World Bank (2010), for instance, estimated the global adaptation costs between US$70 and US$100 billion per year in case of a 2 °C rise in global temperatures by 2050. Although the estimates in these studies have many uncertainties and inaccuracies (Sarkar, Begum, Pereira, &

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Jaafar, 2012) they indicate the enormous investments required, for a large part in physical infrastructure, but also in "soft" measures, such as change in institutions and policies, capacity building, and strategy development (World Bank, 2010). Governments are facing the daunting task of making those adaptation investment decisions that maximise welfare under the constraints of limited budgets and competing demands for resources. In addition, climate adaptation investments cannot be considered in isolation: in most cases climate adaptation is one component in a quest for sustainable development and climate adaptation is an additional criterion – not the main objective – to which a policy or an investment needs to adhere.

Climate adaptation decisions need to be made in an environment characterised by uncertainties. Climate change is a long-term process with many future unknowns and policies, and investment decisions that address climate change usually have a long time horizon. IPCC (2014) projects a temperature rise between 0.3 °C and 4.8 °C by the end of the century as compared to the beginning of last century, with both extremes having very different outcomes. Hence, governments have to deal with uncertain information on phenomena such as sea level rise along their coasts, changes in extreme rainfall events, or occurrence of droughts. In addition, as climate change and adaptation cannot be considered in isolation, the environment and the intrinsically linked social, economic, cultural, political and other systems form sources of many additional uncertainties and ambiguities that affect climate adaptation decisions.

Scientific research in various disciplines attempts to support policymakers in making their decisions in an uncertain context. Traditionally, the work focused on reducing uncertainty through collecting and processing additional data – addressing a lack of information – or by addressing random variation through statistical analysis (Walker, Haasnoot, & Kwakkel, 2013). However, uncertainties in climate adaptation decisions can for the most part not be addressed by addressing a lack of information or statistical analysis: data may simply not exist, for instance on rare, extreme events, and no-one knows how the future will unfold. These "deep uncertainties" are unknowable at present, but can reduce over time (Haasnoot, Kwakkel, Walker, & Ter Maat, 2013; Walker, Marchau, & Swanson, 2010). In response to deep uncertainties, approaches have been developed to help policymakers and system designers in making adaptive plans: plans that are flexible and that can respond when new information appears or when conditions in the environment change. In the context of climate adaptation policy making, relevant approaches are Adaptive Policy Making (Walker, Rahman, & Cave, 2001; Walker et al., 2013), Adaptation Pathways (Haasnoot, Middelkoop, Offermans, Beek, & Deursen, 2012; Reeder & Ranger, 2011) and Real Options Analysis (Gersonius, Morselt, Van Nieuwenhuijzen, Ashley, & Zevenbergen, 2011; Linquiti & Vonortas, 2011; Park, Kim, & Kim, 2014). In addition, there are many other methodologies, tools and techniques to deal with uncertainties in general. A few examples are: scenario planning (Swart, Raskin, & Robinson, 2004), Monte Carlo Analysis (Zhang & Babovic, 2012), Multi-layer Decision Analysis (Harvey, Hall, & Peppe, 2012) and safety margin strategies (Hallegatte, 2009). Methodologies and tools are often complementary, used in combination and can be developed for a specific context. The level of uncertainty they address – lack of data versus deep uncertainty – also varies. In order to develop robust climate adaptation strategies, correct framing of uncertainty and selection of appropriate approaches, methodologies and tools is of great importance.

In this setting, the objective of this paper is to analyse the levels, types and sources of uncertainty in climate adaptation policy making (Section 2), develop a conceptual framework to deal with these uncertainties in a structured manner based on the approaches of Adaptive Policy Making, Adaptation Pathways and Real Options Analysis (Section 3), and demonstrate the framework to policy making for pluvial flood protection in Singapore (Section 4).

2. Uncertainty in policy making for adaptation to climate change

2.1. Adaptation to climate change

In general, the aim of investments and policies for adaptation to climate change is to reduce the risks that individuals and societies face from extreme weather events and other climate and weather related impacts (IPCC, 2014). For a clear understanding of uncertainty in policy making for adaptation to climate change it is important to clearly define a number of concepts that are often used in the current adaptation literature.

Firstly, adaptation to climate change is a very broad concept that can encompass different types, different attributes and different applications of adaptation (Smit, Burton, Klein, & Wandel, 2000). For instance, adaptation can be reactive or proactive, can occur in natural systems or socio-economic systems and can be targeted at different climatic variables. For this reason one needs to define clearly the system that adapts, to what the system adapts and how the system adapts (Haasnoot et al., 2013; Smit et al., 2000).

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