Knowledge for Climate

Uncertainty Terminology

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Content

1 Introduction

This document is intended to provide an overview of the wide variety of terms and concepts that are being used when discussing uncertainty. This document has been written in response to an expressed need by the Knowledge for Climate theme 2 consortium to get some clarity on the terminology that is being used when discussing uncertainty in various scientific and policy domains. This document has been written by the researchers working on projects belonging to work package 5 on uncertainty.

Knowledge for climate is a research program that is developing knowledge and services that can be used to support investment decisions in spatial planning and infrastructures with respect to their climate proofing. Uncertainty is intrinsic to these decisions. However, since uncertainty is so intrinsic to these decisions, the various policy domains and scientific fields have all developed their own terminology for discussing uncertainty. It is the hope that the offered overview in this document can create some clarity on these terms and facilitate communication across domains and scientific fields.

The overall structure and selection of terms represent the expressed interest of the researchers of work package 5. That is, the document is divided into two main parts: key concepts and glossary. The key concepts part focuses on the main concepts that are expected to be used in work package 5. The glossary contains a wider overview of terms. For various terms, multiple definitions are given that may be encountered in the literature. Before turning to the key concepts, some background is provided. The key concepts are to be understood against this background.

The definitions and concepts are provided in English. This is a deliberate choice, motivated by the scientific character of the Knowledge for Climate program. It is however, the intention that at some future date, this document will be extended and will address the Dutch uncertainty terminology as well. This brings us to the final point: this document is intended to be used as a living document. That is, the document is expected to be expanded and modified over the course of time. Readers are therefore explicitly invited to share comments and questions with the authors, either in person or via e-mail. These comments can be send to j.h.kwakkel@tudelft.nl.

2 Background

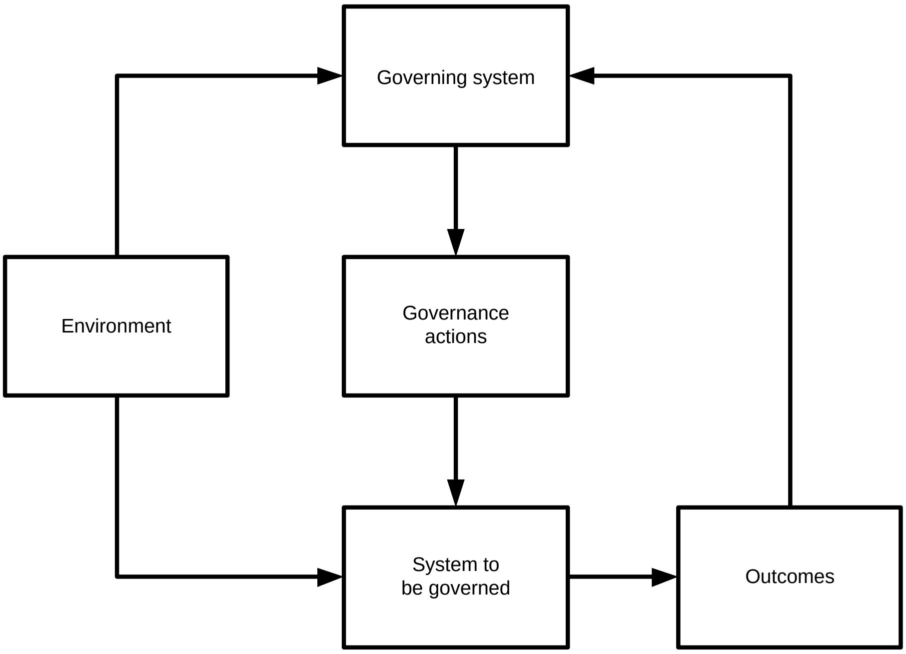
Over the last few decades, interest has risen in supporting governmental decision making using science-based knowledge and tools. We in particular focus here on support for strategic long-term decisionmaking problems, which are typically ill-structured in character (Gorry and Morton, 1971). Although there exists a wide variety of approaches and schools of thought on decision support, most of them rely on some form of systems thinking that emphasizes the need to analyse a decisionmaking problem within its context. Many of the relevant terms and concepts that will be defined in this document implicitly rely on systems thinking as a background. Therefore, we first introduce some basic notions from systems thinking.

2.1 A systems framework

Figure 1 shows a system analytic framework that can be used to structure decision support activities. Note that this framework is just one way in which systems can be conceptualized. The governing system is primarily social. It consists of the institutions and steering mechanisms, such as organizations and legal rules (Jentofts et al., 2007). The system-to-be-governed is typically a mixture of social, technical, physical, and ecological components (Jentofts et al., 2007). The governing system interacts with the system-to-be-governed. Actors in the governing system enact governance actions on the system-to-be-governed, while outcomes of the system-to-be-governed affect the governing system. Governance actions are typically instigated by one or more actors in the governing system to guide the system-to-be-governed towards a functioning that is deemed more desirable by the instigating actors (Kooiman and Bavinck, 2005).

There is a separate theme on governance within the overall Knowledge for Climate program. There, governance is defined as the interactions between public and/or private entities ultimately aiming at the realization of collective goals. This broad definition comprises governing activities of governments, businesses, and civil-society actors; it encompasses economic, communicative, and regulatory steering mechanisms; and it embraces both structure and process. This definition of governance is coherent with the notion of governing system used here.

Figure 1: A systems framework



The distinction between system-to-be-governed and governing system can be applied recursively. For example, the Dutch Parliament is typically an important actor in the governing system. However, in debates about limiting the number of members of Parliament, it also appears as the system-to-be-governed. This recursion also implies that the actors in the system-to-be-governed can partially or completely overlap with the actors in the governing system. However, from an analytical perspective the role of the actor is different depending on whether one is analysing the governing system or the system-to-be-governed.

Governance actions are sometimes called policies, tactics, strategies, or management actions. For this document, it is suggested to make a tripartite distinction between governance, policy or strategy, and management. Governance is the most inclusive term and is focused on the longer-term societal needs, policies are aimed at addressing particular problems with respect to a given function of the system-to-be-governed, and management actions are operational in character (Kooiman and Bavinck, 2005).

Both the system-to-be-governed and the governing system do not exist in isolation. They are embedded in a wider environment that influences both of them. The environment of the system-to-be-governed is typically a mixture of social, technical, and ecological forces, while the governing system is primarily though no exclusively influenced by a social environment (Jentofts et al., 2007).

The system-to-be-governed produces various outputs that in turn can affect the governing system. From a policy analytic perspective, only those outcomes that are relevant for the actors involved in the decision making on a specific issue are relevant to be taken into consideration in the analysis (Walker, 2000). Typically, these outcomes are somehow related to the societal need the system-to-be-governed is meeting. That is, given system-to-be-governed exists because it meets one or more societal needs. These societal needs can also be understood as the functions of the system-to-be-governed (de Haan, 2010).

The framework depicted in Figure 1 is very generic. More specific versions of it can be found in the literature. For example, Walker (2000) uses a policy analysis framework that focuses primarily on the system-to-governed, its environment, its outcomes, and the actions that are being considered for a specific policymaking problem.

For any analysis, clearly delineating the system-to-be-governed and the governing system is crucial. Such delineations cannot be assumed obvious and can have large consequences for the interpretation of terms used in the analysis, such as robustness or resilience. Confusion can be avoided only by being explicit on the boundaries of both systems,

2.2 Uncertainty

Uncertainty and its treatment have always been important elements in decision support. Uncertainty can be defined as any departure from the unachievable ideal of complete determinism (Walker et al., 2003). Uncertainty is not simply a lack of knowledge, since an increase in knowledge might lead to an increase of knowledge about things we don't know, and thus increase uncertainty. Given the importance of uncertainty in decisionmaking, and the reliance of decisionmaking on scientific advice, a wide variety of scientific disciplines have their own terminology for discussing uncertainty. In an attempt to harmonize these literatures in as far as they relate to model-based decision support, Walker et al. (2003) presented an uncertainty framework. The starting point for this framework is the distinction between an analyst's perspective on uncertainty and a decision maker's perspective on uncertainty (van Asselt, 2000). The framework than focuses on the analyst's perspective on uncertainty. A central idea of this framework is that uncertainty is a multi-dimensional concept. Ironically, this framework in turn had its own variants, motivated by various perceived shortcomings of the original typology or perceived need to tailor it to a specific field of study. Most recently, Kwakkel et al. (2010b) presented a review of the variants and what motivated them, and presented a new framework that integrated and harmonized the variants. Both the original and the new framework categorize uncertainties by their location, nature, and level. The location dimension focuses on where the uncertainty is located. The nature dimension focuses on the character of the uncertainty. The level dimension focuses on the severity of the uncertainty.

Each of the three dimensions is relevant when selecting an appropriate approach for handling the uncertainty. However, the level dimension plays the most important role. Broadly speaking, the level of uncertainty is the assignment of likelihood to things or events. In some cases the likelihood or plausibility of these things, events or situations can be expressed using numbers, but in other cases more imprecise labels are used, such as more likely, less likely, or equally likely. Overall, the level of uncertainty ranges from complete certainty to absolute ignorance. We define five intermediate levels of uncertainty: we speak of level 1 uncertainty, or recognized uncertainty, when one admits that one is not absolutely certain but when one is not willing to measure the degree of uncertainty in any explicit way (Hillier and Lieberman, 2001). We speak of Level 2 uncertainty, or shallow uncertainty, when one is able to enumerate multiple possibilities and is able to provide probabilities. We speak of Level 3 uncertainty, or medium uncertainty, when one is able to enumerate multiple possibilities and able to rank order them in terms of perceived likelihood. However, how much more likely or unlikely one possibility is compared to another cannot be specified. We speak of Level 4 uncertainty, or deep uncertainty, when one is able to enumerate multiple possibilities without being able or willing to rank order the possibilities in terms of how likely or plausible they are judged to be. Finally, we speak of Level 5 uncertainty, or recognized ignorance when one is unable to enumerate multiple possibilities, while admitting the possibility of being surprised (Kwakkel et al., 2010b). Table 1 summarizes the five levels.

Table 1: The five levels of uncertainty (adapted from Kwakkel et al., 2010b)

Level of Uncertainty	**Description**	**Examples**
Level 1 (recognized uncertainty)	Recognizing that one is not absolutely certain, without being able or willing to measure the uncertainty explicitly.	Performing a sensitivity analysis on a parameter in a model by changing its default value with some small fraction
Level 2 (shallow uncertainty)	Being able to enumerate multiple alternatives and being able to provide probabilities (subjective or objective)	Being able to enumerate multiple poss futures or alternative model structures and specify their probability of occurri
Level 3 (medium uncertainty)	Being able to enumerate multiple possibilities and being able to rank order the possibilities in terms of perceived likelihood. However, how much more likely or unlikely one alternative is compared to another cannot be specified	Being able to enumerate multiple poss futures or alternative model structures and being able to judge them in terms perceived likelihood
Level 4 (deep uncertainty)	Being able to enumerate multiple possibilities without being able to rank order the possibilities in terms of how likely or plausible they are judged to be	Being able to enumerate multiple poss futures or specify multiple alternative model structures, without being able t specify their likelihood
Level 5 (recognized ignorance)	Being unable to enumerate multiple possibilities, while admitting the possibility of being surprised	Keeping open the possibility of being wrong or being surprised

2.3 A new paradigm for handling uncertainty

Uncertainties pose a significant challenge to planning and decision making. The dominant approach in many fields has been to ignore the uncertainties, to quantify them into error margins, to try and reduce them, or to deal with only those uncertainties that can be easily quantified (Quade, 1982, Dempsey et al., 1997, Marchau et al., 2009, Van Geenhuizen et al., 2007, van Geenhuizen and Thissen, 2007, McDaniel and Driebe, 2005). However, such approaches suffer from the problem that they focus on those uncertainties that are “among the least of our worries; their effects are swamped by uncertainties about the state of the world and human factors for which we know absolutely nothing about probability distributions and little more about the possible outcomes” (Quade, 1982). Similarly, Goodwin and Wright (2010) (p. 355) demonstrate that “all the extant forecasting methods – including the use of expert judgment, statistical forecasting, Delphi and prediction markets – contain fundamental weaknesses.” And Popper, et al. (2009) state that the traditional methods “all founder on the same shoals: an inability to grapple with the long-term’s multiplicity of plausible futures.” In response to this, various new planning approaches have been put forward (e.g. Lempert et al., 2003, Walker et al., 2001, de Neufville, 2000, de Neufville, 2003, Dewar, 2002, Dewar et al., 1993, Holling, 1978, Lempert, 2002). On the one hand (Swanson et al., 2010), these approaches emphasize the need for a more thorough integrated forward-looking analysis of the uncertainties through techniques such as exploratory modelling and analysis (Agusdinata, 2008, Lempert et al., 2003), bounce casting (Kahan et al., 2004), and scenarios in various forms (Bradfield et al., 2005, Varum and Melo, 2010). On the other hand, because of the limited capability of these techniques for anticipating rare events (Goodwin and Wright, 2010), there is a growing interest in flexibility and adaptability in plans in which a strategic vision of the future is combined with short-term actions and a framework that can guide future actions (Albrechts, 2004, Walker et al., 2001, Walker et al., 2010). Lastly, resilience-based strategies focus on the system-to-be-governed itself, and try to enhance the system’s ability to cope with disturbances and its self-organizational capacity in a comprehensive way (e.g Wardekker et al., 2010) Together, these new approaches can be considered to form a new emerging paradigm for handling uncertainty differently. They are based on accepting the uncertainties, and focusing on the question what can best be done now, given that we don’t know what the future will bring. The key concepts introduced in the next section are concepts central to this new paradigm.

2.4 The role of time

A final aspect that requires clarification is the role of time. Many concepts related to uncertainty use terms like change, trend, disturbance, or recovery.

What is the difference between a change and a disturbance? What is considered to be a reasonable speed of recovery? Answers to such questions require a clear specification of the time horizon that is taken into consideration. If the time horizon of the analysis is thirty years, an event with a one year duration can be considered a disturbance, while if one has a significantly shorter horizon, it might be a change or trend. This suggests that these concepts should be understood relative to the time horizon of the analysis. The same also applies to concepts such as recovery or bounce back. Another aspect of time is how a system is analysed. Does one look at the system for a given point in time, or does one study the dynamics of the system over time? Similarly, is the system defined exactly as it is today (static), or defined in terms of general/key characteristics while the specific composition may change over time (internally dynamic). In any analysis, clarity should be provided also on this issue.

3 Key Concepts

3.1 Adaptive policy

An adaptive policy is designed to be changed over time as new information becomes available, so that policy makers can respond to surprises when (and if) they occur. Adaptive policymaking (Walker et al., 2001, Kwakkel et al., 2010a) is a stepwise approach for developing adaptive policies taking into account the multiplicity of plausible futures.

Adaptive policymaking (APM) is one approach that fits with the emerging new paradigm on handling uncertainty in decision making. Compared to adaptive management (Holling, 1978, Lee, 1993), APM emphasizes the pre –specification of a monitoring system and of a set of actions to adapt the policy to how the future enfolds. In contrast, adaptive management is mainly about experimenting and learning about the system-to-be-governed through these experiments. APM is mainly focused on the design of policy actions that dynamically steer the system-to-be-governed towards a functioning that is deemed more desirable.

Related concepts: adaptive management, deep uncertainty, flexibility

3.2 Flexibility (NL: flexibiliteit)

Different definitions of 'flexibility' can be found. For example, 'Flexibility is the ease with which a system or policy can be adapted to changing circumstances' (Floodsite, 2005). Or alternatively, Flexibility "(…) may be defined as the ability of the organization, policy, or system to adapt to substantial, uncertain, and fast-occurring (relative to required reaction time) changes that have a meaningful impact on the organization's, policy's, or system's performance." (modified from Aaker and Mascarenhas, 1984).

Both definitions are partially appealing. The first one is quite generic and focuses on flexibility as being something that gives the possibility to adapt a system or policy. The second definition emphasizes the importance of the reaction time to the notion of flexibility, while it speaks of the ability of a system or policy to adapt itself. Our proposed definition is "Flexibility is the ease with which a system or policy can be adapted to substantial, uncertain, and fast-occurring changes that have a meaningful impact on the system or policy performance" What can be considered fast-occurring change is dependent on the time-horizon that is being used in the analysis.

In using the notion of flexibility, it is relevant to specify what it is that is flexible (the policy, or part of the policy, the system, or an element in the system), and for what kinds of changes this flexibility is to be used.

Flexibility can be contrasted with lock in. It is an enabler for adaptive policies. An example of creating a certain flexibility is the spatial reservation, such as currently being used around Amsterdam Airport Schiphol. This spatial reservation creates the flexibility to add an additional runway to the airport in the future if this is deemed necessary.

Related concepts: adaptive capacity, robustness

3.3 Resilience (NL: veerkracht)

Resilience is defined in the literature in many different ways. A widely used definition for resilience is resilience as the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks (Walker *et al.*, 2004). This definition (and closely related alternatives) is applied to social-ecological systems and is widely used among the resilience community, for instance within the Resilience Alliance. The general idea behind the focus on resilience for climate change adaptation is that, while estimates of the actual impacts of climate change are not reliable, due to major uncertainties that are present, one might still be able to strengthen the resilience of the affected system (Dessai and Van der Sluijs, 2007).

Special point of attention when setting up a study on resilience, is the identification of system boundaries, and the interaction of the system with systems below and above. The determination of system boundaries has to be in close collaboration with the identification of the functions that are practiced by the system and has to be secured (resilience *of* what, see for instance Carpenter *et al.*, 2001). When it comes to climate change adaptation, some elements from the definition by Walker *et al*. are not necessarily indispensable to increase the resilience of any impacted system. Especially the terms structure and identity are rather ambiguous, and seem not to be essential in operationalizing the concept resilience, as long as the system functions are guaranteed. Even the existing feedbacks in a system would no longer have to be of the same importance under future stress, or might even be replaced (partly) by other feedback mechanisms. So we suggest to use as working definition of resilience: the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same functions.

Another point of attention are the kind of external stresses and perturbations the system has to be resilient to (resilience *to* what). These can be investigated among others by statistical and scenario based explorations of current and expected trends, complemented with the use of wildcards to protect from surprises as much as possible (e.g. Wardekker *et al.*, 2010).

Characteristics of the resilience of linked social-ecological systems are (Carpenter et al., 2001) :

- The amount of change the system can undergo and still retain essentially the same function and structure
- The degree to which the system is capable of self-organization
- The ability to build and increase the capacity for learning and adaptation

Related concepts: adaptive capacity

3.4 Robustness (NL: robuustheid)

Robustness refers to the degree of insensitivity of the system performance or decision outcome to fluctuations or changes in conditions. To further define the concept, it is useful to distinguish between system robustness and decision robustness (Mens et al., under review).

System robustness is the ability of a system to remain functioning under a range of conditions.

What system robustness means in practice depends on the type of system and the scale on which it is applied. The degree of system robustness depends on how 'system functioning' is defined and measured, and to what conditions it should be robust. We give two examples.

Imagine a network of canals with the function to supply sufficient surface water to the users. When this system fails, it means there is a water shortage. A robust system will be able to provide enough fresh water. Obviously, what is 'enough' should be properly defined. In this example, the economic consequences of a water shortage are not seen as part of the system. The conditions to which the system should be robust could be the surface water demand, which depends on the type of use (shipping, farming, drinking water).

Now the fresh-water supply system is combined with the socio-economic system, i.e. the fresh-water users and their income. In this system definition a lack of fresh-water supply is not necessarily a system failure, since the users may have alternative sources of fresh water, alternative ways to earn money, or simply can deal with some damage.

These two examples show that the meaning of system robustness depends on how 'system functioning' is defined and measured, and to which conditions it should be robust. It is possible to combine different types of conditions, e.g., system robustness could be analysed for fluctuations in both surface water supply and rainfall.

Decision robustness is the degree to which a decision or policy performs well under a range of conditions (Lempert et al., 2003)

A robust decision is the choice for a policy or strategy that performs well under a range of conditions. To apply this concept in practice, 'conditions' and 'performs well' should be defined. Conditions could be future developments, which are often described in the form of scenarios (climate change scenarios, land use change scenarios, etc.). A robust strategy performs well under different scenarios. Whether a strategy 'performs well' depends on the chosen decision making criterion, for example the benefit/cost-ratio.

Conditions could also refer to the decision-support model for which assumptions are needed (e.g. in terms of model structure and parameter settings). A robust decision then means that the eventual decision outcome is insensitive to changes in these assumptions.

One way of developing a robust policy is to build in flexibility, i.e., to increase the ability of the (physical) system to be adapted to changed conditions in the future (e.g., reserving a piece of land that may be used to strengthen dikes in the future). This does not change the system robustness *at present*, since the range of conditions it can *currently* cope with is not modified. However, because the policy allows dike strengthening in the future (if needed), it will perform better under a range of future conditions than a policy without this built-in flexibility. Flexibility is thus a means to achieve decision robustness.

Related concepts: (Deep) uncertainty, flexibility, adaptation, adaptive policymaking, scenario

3.5 Scenario

A scenario is a plausible and often simplified, description of how the future may develop, based on a coherent and internally consistent set of assumptions about driving forces and key relationships. Scenarios can be defined as a rich and detailed portrait of plausible futures world or as futures states of a system. Thus, scenarios always come as a set, and never alone (Goodwin and Wright, 2010). Moreover, scenarios have no predictive value whatsoever (Enserink et al., 2010). Scenarios indicate what *might* plausibly occur, in contrast to forecasting techniques that aim to predict as accurately as possible what is *likely* to happen. Scenarios can be used to give information on the possible future trajectories of a system, when the current scientific knowledge base does not allow for more specific projections (e.g. probability of future impacts represented in statistical terms). To capture (deep) uncertainties about the future system state, its future trajectory is expressed in terms of plausible outcomes (Knol et al., 2009). Plausibility is what distinguishes sound analytical scenarios from mere fantasy (Schwartz, 1991, van der Heijden, 1996, Enserink, 2000). Scenarios can be used for the various components specified in the system framework. Thus scenarios can cover the environment, the governing system, the system-to-be-governed, and/or the outcomes.

During the last decennium, working with scenarios has become very popular within the government, as well as within the trade and industry sectors. At the same time, the use of the term has strongly broadened. Therefore, it is difficult to speak of 'the' scenario-approach. Relevant distinctions include whether a scenario describes of point in the future, or a transient pathway to a future; whether the scenario is *contextual, policy-oriented,* or *strategic*, and whether the scenarios are normative or descriptive (Enserink et al., 2010). Contextual scenarios provide images of possible future environments of the policy (that needs to be designed) or system that is taken into account. They are mainly used to make statements about the robustness of possible policies. These scenarios focus on the environment or context of the problem that cannot be influenced by the policymaker, but that can significantly influence the results of a policy. Van der Heijden's (1996 p. 5) speaks of an "external scenario". He says "external scenarios [. . .] are created as internally consistent and challenging descriptions of possible futures. [. ..] What happens in them is essentially outside our own control." The scenarios are used to address the ways that the basic policy could go wrong (i.e., not lead to success). Thus, they do not have to be as detailed as scenarios used for developing a new (robust) policy. Policy-scenarios on the other hand describe possible developments of the problem or system itself, where the problem owner or policymaker can influence the choices that give direction to the development. In policy-scenarios, the context of the policy is presumed to be more or less constant. Strategic scenarios deal with images of the whole, i.e. they combine policies and contextual developments. Strategic scenarios are used to make a strategic choice between a (limited) number of kinds of development or policies clear and discussable, by providing insight into the expected effects.

Related concepts: (Deep) uncertainty, Adaptation

4 Glossary

This glossary contains a set of terms that are somehow related to the key concepts, but not expected to be as central to the research to be carried out in WP 5. We also included the definitions for the key concepts for completeness.

4.1 Adaptation

Adaptation is the modification of ecological and social systems to accommodate changes so that these systems can persist over time (modified from Barnett, 2001).

4.2 Adaptation pathway

An adaptation pathway describes a sequence of policies which can be used for adapting to changing conditions. In contrast to a climate change scenario, which provides a set of values for climate variables at one or two times in the future (e.g., 2050 and 2100), a pathway provides a description of a possible series of interventions over time. An adaptation pathway is a pathway that includes the effects of policy measures (e.g., policies developed for the purpose of (climate change) adaptation) (adapted from Haasnoot et al., 2009).

4.3 Adaptive capacity (NL: adaptief vermogen)

Adaptive capacity is the ability of the governing system to plan, prepare for, facilitate, and implement adaptation options. Factors that determine a community's adaptive capacity include its economic wealth, its technology and infrastructure, the information, knowledge and skills that it possesses, the nature of its institutions, its commitment to equity, and its social capital (Floodsite, 2005).

4.4 Adaptive policymaking

An adaptive policy is designed to be changed over time as new information becomes available, so that policy makers can respond to surprises when (and if) they occur. Adaptive policymaking (Walker et al., 2001, Kwakkel et al., 2010a) is a stepwise approach for developing adaptive policies taking into account the multiplicity of plausible futures. In short: determine objectives and vulnerabilities, determine hedging (certain) & mitigating (uncertain) options and monitor if you need to reassess, corrective actions and/or defensive actions. based on Assumption Based Planning (Dewar, 2002, Dewar et al., 1993).

4.5 Adaptive management

Adaptive management identifies uncertainties, and then establishes methodologies to test hypotheses concerning those uncertainties. It uses management as a tool not only to change the system, but as a tool to learn about the system (Resilience Alliance).

A central idea in adaptive management is that the system is only partially understood. By conducting carefully constructed experiments and explicitly monitoring their effects, one can learn more and more about the workings of the system. It originated in the work of Holling (1978). Lee (1993) presents an extensive overview.

4.6 Deep Uncertainty (NL: diepe onzekerheid)

Deep uncertainty is as a situation in which decisionmakers do not know or cannot agree on a system model, the prior probabilities for the uncertain parameters of the system model, and/or how to value the outcomes (Lempert et al., 2002).

Being able to enumerate multiple possibilities without being able or willing to rank order the possibilities in terms of how likely or plausible they are judged to be (Kwakkel et al., 2010b).

Note that although these definitions are coherent, the latter is more restrictive. They are coherent since in case of situations where one cannot agree on e.g. the system model, multiple possible system models can still be specified. The inability or unwillingness to rank order follows from this, for any rank ordering is subject to be contested in case of disagreement, or cannot be grounded in case one does not know. The latter definition is more restrictive in that it still assumes that it is possible to enumerate multiple possibilities. This is not required by the first definition.

4.7 Flexibility (NL: flexibiliteit)

Flexibility is the ease with which a system or policy can be adapted to substantial, uncertain, and fast-occurring changes that have a meaningful impact on the system or policy performance.

4.8 Policy tipping point (NL: beleidsknikpunt)

A policy tipping point is a point where the magnitude of change is such that the current management strategy can no longer meet its objectives (Kwadijk et al., 2010).

Note that this definition is used by Kwadijk et al. to define 'tipping point' or 'adaptation tipping point'. To emphasize its relation to the current management strategy and to distinguish it from the way the term is used in climate science or complexity science, it is recommended to always use the prefix 'policy'.

4.9 Resilience (NL: veerkracht)

Resilience is the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same functions.

4.10 Resistance (NL: weerstand)

Resistance is the ability of a system to withstand disturbances or changes (adapted from de Bruin, 2004). To withstand means that the disturbance or change does not enter the system. For example, a storm surge barrier will protect an area from high seawater levels, by preventing that the water flows into the hinterland.

4.11 Robustness (NL: robuustheid)

Robustness refers to the degree of insensitivity of the performance of a system or decision to fluctuations or changes in conditions. It is advised to distinguish between system robustness and decision robustness.

System robustness is the ability of a system to remain functioning under a range of conditions

Decision robustness is the degree to which a decision or policy performs well under a range of conditions (Lempert et al., 2003)

4.12 Scenario (NL: scenario)

A scenario is a plausible and often simplified, description of how the future may develop, based on a coherent and internally consistent set of assumptions about driving forces and key relationships. Scenarios can be defined as a rich and detailed portrait of plausible futures world or as futures states of a system.

4.13 Signpost

Signposts are indicators whose development should be tracked in order to determine whether a policy is achieving its goals (Kwakkel et al., 2010a).

4.14 Strategy (NL: strategie, maatregelenset, of beleidsalternatief)

A strategy is a combination of long-term goals, aims, specific targets, technical measures, policy instruments, and processes that are continuously aligned with the societal context (Floodsite, 2005).

4.15 Threshold

A threshold is a critical system state value, where a sudden change in system response occurs. Sometimes a threshold indicates a regime shift. A regime shift occurs when a threshold level of a controlling variable in a system is passed, such that the nature and extent of feedbacks change, resulting in a change of direction (the trajectory) of the system itself (Walker and Meyers, 2004).
Related concepts: policy tipping point

4.16 Trigger

Triggers are critical values of signpost variables at which adaptation actions are suggested (Kwakkel et al., 2010a).

Related concepts: policy tipping point

4.17 Uncertainty (NL: onzekerheid)

Uncertainty is any departure from the unachievable ideal of complete determinism. Uncertainty is not simply a lack of knowledge, since an increase in knowledge might lead to an increase of knowledge about things we don’t know and thus increase uncertainty (Walker et al., 2003).

4.18 Vulnerability (NL: kwetsbaarheid)

Vulnerability is a characteristic of a system that describes its potential to be harmed. This can be considered as a combination of susceptibility and value (Floodsite, 2005).

Note that vulnerability is also a technical term in the context of adaptive policymaking. For more details on this particular use, see (Kwakkel et al., 2010a).

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To develop the scientific and applied knowledge required for Climate-proofing the Netherlands and to create a sustainable Knowledge infrastructure for managing climate change

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