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Scenarios, Their Characteristics and Uses

1.1 DEFINING SCENARIOS

A scenario is a description of potential future conditions, developed to inform decision-making under uncertainty. The decisions in question can be faced by individuals, groups, organizations, or governments, and may pertain to any subject matter. While many writers on scenarios give no explicit definition, others have offered a wide range of definitions, often substantially more complex and restrictive than this one. The published definitions gathered in Box 1.1 give a sense of both the broad commonalities among many analysts' conceptions and the significant differences among them.

BOX 1.1 Scenarios: a Sampling of Published Definitions.

A scenario is a coherent, internally consistent, and plausible description of a possible future state of the world.[5]

A scenario is a story that describes a possible future. It identifies some significant events, the main actors and their motivations, and it conveys how the world functions. Building and using scenarios can help people explore what the future might look like and the likely challenges of living in it.[6]

Scenarios are images of the future, or alternative futures. They are neither predictions nor forecasts. Rather, each scenario is one alternative image of how the future might unfold. A set of scenarios assists in the understanding of possible future developments of complex systems. Some systems, those that are well understood and for which complete information is available, can be modeled with some certainty, as is frequently the case in the physical sciences, and their future states predicted. However, many physical and social systems are poorly understood, and information on the relevant variables is so incomplete that they can be appreciated only through intuition and are best communicated by images and stories. Prediction is not possible in such cases.[7]

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[5]   IPCC 2001b:149.

[6]   Shell International 2003.

[7]   Nakicenovic and Swart 2000:62.

BOX 1.1, continued from previous page.

A climate scenario is a plausible representation of future climate that has been constructed for explicit use in investigating the potential impacts of anthropogenic climate change. Climate scenarios often make use of climate projections (descriptions of the modeled response of the climate system to scenarios of greenhouse gas and aerosol concentrations), by manipulating model outputs and combining them with observed climate data.[8]

[Scenarios] are created as internally consistent and challenging descriptions of possible futures. They are intended to be representative of the ranges of possible future developments and outcomes in the external world. What happens in them is essentially outside our own control.[9]

Scenarios are coherent, internally consistent and plausible descriptions of possible future states of the world, used to inform future trends, potential decisions, or consequences. They can be considered as a convenient way of visioning a range of possible futures, constructing worlds outside the normal timespans and processes covering the public policy environment.[10]

Scenarios are plausible, challenging, and relevant sets of stories about how the future might unfold. They are generally developed to help decision-makers understand the wide range of potential futures, confront critical uncertainties, and understand how decisions made now may play out in the future. They are intended to widen perspectives and illuminate key issues that might otherwise be missed or dismissed. The goal of developing scenarios is often to support more informed and rational decision-making that takes both the known and the unknown into account.[11]

The historical uses of scenarios for planning and analysis lie in war games, exercises of simulated conflict used for military training, planning, and operational decision-making. The roots of war games extend to antiquity, although the first formalized war games were developed for officer training in 19th-century Prussia.[12] In the 1940s and 1950s, exercises resembling war games began to be applied outside the purely military domain, to study potential international crises that included both high-level political decision-making and the potential for military conflict. These exercises were informed by the then-new field of game theory, which promised new formal insights into situations of conflict and strategic decision-making,[13] motivated by the recognition that the new nuclear age had both raised the stakes of international diplomacy and created profound new uncertainties over how to proceed. In these exercises, principally developed at the Rand Corporation, scenarios were sketches of challenging but plausible situations to which participants had to respond, allowing exploration of associated threats and opportunities. They adopted the term "scenario" from film and theatre, where it denotes a brief sketch of a story that includes only enough detail to convey broad points of plot and character. As in classic war games, scenarios in these exercises served to help organizations and their leaders prepare for novel, complex challenges that they might not anticipate, and which – if they did arise – would likely develop too fast to allow adequate reflection or analysis in real time.[14]

Over the past few decades, the use of scenarios has moved outside the realm of military and diplomatic activity. Beginning with strategic planning at the Royal Dutch/Shell oil company,[15] scenarios are now widely used for strate-

8   IPCC 2001a:741.

9   van der Heijden 1996:5.

10   Berkhout et al. 2001:i.

11   MEA 2006:xvii.

12   Brewer and Shubik 1979.

13   Von Neumann and Morgenstern 1944, Nash 1950.

14   Levine 1964a,b; Schelling 1964; DeWeerd 1967, 1975; Brewer and Shubik 1979.

15   For relevant history, see Hausrath 1971, Shubik 1975, Greenberger et al. 1983, Huss 1988, Schoemaker 1995, Schultz and Sullivan 1972, Schwartz 1991, Shell International 2003.

gic planning, analysis, and assessment by businesses and other organizations. They have also figured increasingly prominently in planning, analysis, and policy debate for long-term environmental issues, in particular global climate change. Because the total body of experience with scenarios provides useful insights into their use in any particular domain, this section elaborates the meaning, characteristics, and potential uses of scenarios in general. The next section turns to their specific use for global environmental issues.

1.1.1 Distinguishing scenarios from assessments, models, and analyses

Confusion is widespread in discussions of scenarios, because their form and usage are highly diverse, and because writers' uses of the term are often imprecise and occasionally contradictory. Scenarios must be distinguished, on the one hand, from assessments and various types of decision support activity that often use scenarios; and, on the other hand, from other types of statements about future conditions, such as predictions, projections, or forecasts.

An assessment is any process that reviews and synthesizes scientific or other expert knowledge to provide information of relevance to policy- or decision-makers.[16] The most common methods of assessment are deliberations of expert panels and formal models, but other methods combine human deliberations with formal analysis or modeling, including war games or other simulation games, policy exercises, political-military exercises, constructing future histories, backcasting, and others.[17] These methods may use specifications of potential future conditions – i.e., scenarios – as inputs to or components of their work. Scenarios may even be essential for some of these methods. For example, a war or crisis gaming exercise needs a scenario to specify the nature of the threat or crisis, while a formal model used to represent future development of some issue of concern needs a scenario to specify future values of those inputs not explicitly calculated within the model. But

these methods are broader than and distinct from scenarios. For example, models do not need scenario-based inputs when used to reconstruct past conditions or study causal processes.

The distinction between assessments and scenarios is perhaps clearest in conventional assessments based on deliberations of expert panels, such as the IPCC, US National Assessment, or Millennium Ecosystem Assessment (MEA). Such assessments often construct representations of future development of an issue, usually based on formal models. These representations require scenario-based inputs and may produce outputs that are themselves used as scenarios in other activities. But the scenario-related activities are frequently not the central focus of the overall assessment, which may examine many additional things, e.g., the state of knowledge in particular scientific areas, the status of and trends in particular environmental conditions, the evidence attributing particular environmental changes to human inputs, or particular policy-relevant scientific questions. Assessments may also include evaluations of proposed actions or proposed criteria for conducting such evaluations. Scenarios thus may provide required inputs to assessments, but are distinct from them.

1.1.2 Distinguishing scenarios from projections, predictions, and forecasts

Scenarios must also be distinguished from other types of statements about the future, such as predictions, projections, and forecasts. All of these satisfy the basic definition above: they are descriptions of potential future conditions whose primary purpose in most cases is to support decisions. How can scenarios be distinguished? Examining the ways scenarios are used and discussed by practitioners and researchers suggests four characteristics that distinguish them from other types of future statements. Although these characteristics are not essential, they are all more likely to be present in scenarios than in other types of future statement, so they help to sharpen and delimit the definition of a scenario.

First, scenarios are multi-dimensional: they describe multiple characteristics that collectively

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[16]   Parson 2003:9; Mitchell et al. 2006.

[17]   NRC 1996; Hausrath 1971; Brewer 1986; Shubik 1975; Svedin and Aniansson 1987; Schultz and Sullivan 1972; Jones 1985; Parson 1996, 1997.

make up a coherent representation of future conditions. To achieve this, scenarios assemble and organize available knowledge, information, and assumptions from diverse bodies of research and expert judgment. The elements of a scenario can be of diverse types: quantitative or qualitative, precise or fuzzy, based on well-established research or informed speculation. Effective scenarios integrate their diverse elements in a way that is coherent, communicates a clear theme or organizing principle, and avoids internal contradiction.

Second, scenarios are schematic: that is, they are multidimensional but not without limit. Scenarios do not seek to describe potential future conditions with complete precision or detail. Rather, they highlight essential characteristics and processes with enough detail that knowledgeable observers perceive them as realistic and relevant, but not so much as to distract from large-scale patterns. Indeed, one potential use of scenarios is to stimulate creative thinking and insights, for which they must leave something to the imagination. How much detail and precision is appropriate is a judgment that depends on the particular application.

Third, scenarios usually come in groups. To be a useful tool to inform decision-making under uncertainty, scenarios must represent uncertainty. This is most often done by providing multiple scenarios, each presenting an alternative realization of uncertain future conditions.[18] The number of scenarios depends on the application. Scenario exercises usually use between two and seven, depending on the stakes of the issue, the resources invested in the exercise, and the depth of analysis devoted to each scenario. The most frequently proposed numbers are three or four.

Finally, scenarios tend to claim less confidence than other types of future statements. Although different authors' usage is not consistent, "prediction" and "forecast" usually denote statements for which the highest confidence is claimed. "Projection" denotes a less confident

statement, which may have some specified confidence level and may be explicitly contingent on specified assumptions about other future conditions. Calling a future statement a "scenario" usually implies still less confidence and more associated contingencies. Any use of a scenario for serious planning or analysis does, however, presume some minimal threshold of likelihood. The situation described must be judged likely enough to merit attention, and to justify expending resources and effort to study its implications and potential responses to it. There may also be a time ordering among these three types of statements – predictions or forecasts tend to describe nearer-term futures and scenarios longer-term futures – but there are exceptions, and the meaning of near term and long term depend on the particular context.

1.2. CREATING A SCENARIO EXERCISE: KEY CHARACTERISTICS AND CHOICES

Beyond these general characteristics, scenarios vary greatly in their use, production, and contents. Extensive scholarly effort has gone into providing alternative scenario taxonomies.[19] Scenarios can be distinguished, for example, by whether they present a snapshot of a future state or a dynamic account of changes over time to reach that state; by their degree of complexity; by the relative balance of deliberation and intuition versus formal analysis used in producing them; or by their temporal and spatial scale. The set of characteristics on which scenarios could be sorted is long and open-ended, so we make no attempt to provide an exhaustive list. Instead, we summarize the main dimensions of scenario variation in the form of a list of potentially open-ended design choices.

1.2.1 Variation among scenarios: three basic dimensions

Three dimensions of variation, concerned with the purpose of a scenario exercise, have far-reaching implications for its design and use and so merit separate discussion. First, the intended use of a scenario exercise can vary from the

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[18]   Crisis-response exercises are often an exception, presenting one scenario at a time showing a novel challenge, to which participants must respond and which is implicitly contrasted to the status quo.

[19]   See, e.g., Duncan and Wack 1994, Godet and Roubelat 1996, van Notten et al. 2003.

more predictive to the more exploratory or heuristic. It is of course a fundamental error to take a scenario's illustrative description of potential future conditions as a confident prediction of what will actually happen – in our terminology, to take a scenario as a projection or even a prediction.[20] Still, a scenario must be judged likely enough to merit the attention of busy people. Exploratory uses of scenarios may presume only this low threshold, yet have great value. For example, scenarios can be used to probe and challenge the mental models, thought habits, and unrecognized assumptions of decision-makers; to clarify points of agreement and disagreement; to identify and engage needed participants; to provide a preliminary structure for advance analysis of potential future decisions; or to seek insights into unrecognized opportunities, risks, causal linkages, or uncertainties.[21] Such insights can arise not just from examination of uncertainties, but also from meticulous critical examination of future factors that are essentially certain (e.g., strongly determined demographic trends such as the aging of industrialized-country populations) or even of present conditions whose significance has been overlooked.[22] Still, the predictive confidence accorded to scenarios is a matter of degree: carefully developed scenarios that are judged to have captured the most important uncertainties may claim some moderate degree of confidence, and reasonable distinctions may be drawn between scenarios that represent conventional versus surprising futures, best and worst cases, etc.

A related dimension of variation among scenario exercises is their proximity to decision-making.[23] Scenario exercises may involve actual decision-makers and seek to directly advise a specific, identified, near-term decision, but more frequently their relationship to concrete decisions and decision-makers is indirect. Scenarios may be used for risk assessment, contingency planning, identification of potential threats or actions to be considered, or early characterization of a poorly understood issue. In such applications, exploratory uses dominate. Scenario exercises that are closer to decisions with significant stakes operate under very different requirements, usually driven by specific user needs. Their uses tend to be more predictive – constrained by limits of available knowledge – so they might be expected, for example, to provide more explicit and complete characterization of major uncertainties. They are also likely to be more integrated with methods to evaluate alternative choices and identify preferred ones.

A third basic dimension of variation concerns whether scenarios are defined primarily normatively, on the basis of their perceived desirability or undesirability, or primarily on the basis of their perceived plausibility or likelihood. Although all scenarios include both positive and normative elements, it is important to keep as clear as possible which elements are included based on perceived likelihood or plausibility and which because of perceived desirability or undesirability. The most frequent use of explicitly normative scenarios involves constructing some hypothetical future state primarily on the basis of its desirability. Such a future might be constructed to embody participants' general intuitions about desirable social trends, or to achieve specific environmental, development, or other goals.[24] The scenario exercise then consists primarily of backcasting – attempting to construct paths that connect present conditions to the specified future conditions, to examine the feasibility of the target, and identify costs, tradeoffs, and conditions associated with meeting it.[25] Similarly, one can posit an undesirable future state and then reason through con-

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[20]   Several such errors are collected and discussed in Bracken 1977, 1990; and Brewer 1990.

[21]   Brewer 1990.

[22]   Shell International 2001, 2003. For example, in a 1960s crisis exercise on a Soviet invasion of Iran, one participant realized the local supply of jet fuel available to support a rapid US response was ten times larger than had been thought, because kerosene – an acceptable substitute – was used for domestic cooking and heating (Schelling 1994).

[23]   This dimension is presented by Van Notten et al. 2003 as "exploration" versus "decision support."

[24]   See, for example, the simple scenario exercise in NRC (1999:161-176) that posited specific targets to reduce world hunger and greenhouse-gas emissions by year 2050, or the scenarios of the Global Scenario Group, which included some defined by specified trends and others back-cast from normatively specified targets for 2050 (Kemp-Benedict et al. 2002, Raskin et al. 2002).

[25]   Robinson 1982, 2003.

ditions associated with avoiding it. This approach is sometimes proposed to reduce the risks of hidden bias in construction of scenarios which, like any decision support tool, can be misused to provide support for a decision already made for other reasons, rather than to inform a decision not yet made. By bundling normative assumptions into the future target state or boundary conditions, analysts hope to reduce their penetration into the subsequent instrumental reasoning about actions and conditions to reach the target.[26]

1.2.2 Developing scenarios: main dimensions of choice

Table 1.1 extends the preceding discussion, summarizing the main areas of variation and choice involved in constructing a scenario exercise. This is a highly simplified representation of a complex set of choices. In any particular scenario exercise some of these choices may be made by default, without explicit consideration, perhaps because the preferred choice is obvious in context. Although we present these choices in simple sequential order, this is not necessary: choices might be made in some other order, or iteratively adjusted. But while the process and sequence of choices may be idealized, the set of choices is not: creating a scenario requires explicit or implicit choices on all these dimensions.

Table 1.1. Idealized Sequence of Major Choices in Scenario Development.
Main focus, framing, users, question(s) to be addressed
Process and participation
Key uncertainties to explore: how many, over what range
Narrative, quantitative, or both
Level of complexity (number of quantitative variables, detail of narrative)
Specific variables and factors to specify
Time horizon and spatial extent
Temporal and spatial resolution

But whether the relationship of a scenario exercise to decisions is near or far, direct or indirect, clear understanding of its focus and purpose is important, and infrequently achieved.

The most basic choices in developing scenarios, which include the three dimensions of variation called out above, involve identifying the main focus of the exercise: what issues are to be addressed or what decisions informed, for whom? The decision to conduct a scenario-based exercise does not necessarily imply that these matters are clearly understood. The closer a scenario exercise is to concrete decisions, the more likely it is that these definitional issues will be understood clearly, in part through discipline on the process imposed by the involvement of decision-makers. But most often, the coupling of scenarios to decisions is relatively weak.[27] In some applications (e.g., corporate strategic planning, responding to a novel military threat) the relevant decision-makers may be clearly identified at the outset, but the issues to be addressed and relevant choices may not be. In other applications, scenarios may be developed to address some broad issue or concern (e.g., climate change, emerging infectious diseases, or terrorism), but the potential users and decisions to be informed might both be unspecified. But whether the relationship of a scenario exercise to decisions is near or far, direct or indirect, clear understanding of its focus and purpose is important, and infrequently achieved: many scenario exercises muddle through with vagueness, confusion, or disagreement regarding the focus, purpose, and intended user of the exercise. Clarifying the overall focus of a scenario exercise may require broad consultations or scoping workshops involving many potentially interested decision-makers, other stakeholders, and analysts and researchers.

A second basic set of decisions concerns the process by which scenarios are developed. Like the focus of the exercise, decisions about the process of developing scenarios often receive little thought, or are not even explicitly recognized as choices, but are nonetheless highly consequential. What expertise must be included to ensure the scenarios adequately reflect the best available scientific knowledge, data, and models? What decision-makers, stakeholders, or their surrogates must be involved to keep the scenarios relevant, plausible, and credible? For

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[26]   This approach does not preclude such misuse: if a goal is strongly desired, scenarios are at risk of conscious or unconscious bias to make it look easy. Japanese war-games of the Battle of Midway provide striking examples (Bracken 1977).

[27]   E.g., note the predominance of scenarios on the "exploration," rather than the "decision support" side in the survey of Van Notten et al. 2003.

scenario exercises that must integrate knowledge from diverse domains, individual participants' knowledge, flexibility, and imagination can be as important as the disciplines or stakeholder groups they represent. How intensively, for how long, and by what means will participants interact? Will the process be open to outside observers or participants? How and when will feedback on the scenarios be sought, and how will it be used? How and to whom will results be communicated? And crucially, how will the be process be led, and how will disagreements be resolved? With good leadership, resolving differences in a scenario exercise can be less arbitrary and more illuminating than in other group tasks; when disagreements persist after careful examination, they can be treated as important uncertainties to be retained as alternative scenarios, not suppressed by picking a winner, splitting the difference, or retreating to vague language.

Whatever process is chosen, a series of substantive choices must be made about what goes into the scenarios. The most important of these concern what key uncertainties will be explored, and how much richness and detail should be included in scenarios to illuminate these.

What uncertainties are to be explored, and how? Many dimensions of uncertainty may be relevant to the issue being examined, but only a few can be examined explicitly in any scenario exercise. Defining these is a crucial choice that shapes much of what follows in a scenario exercise. For those uncertainties judged most important, alternative outcomes are usually represented in alternative scenarios. For example, scenarios might present high- and low-growth futures, or alternative forms that a competitive threat might take. Other uncertainties judged less crucial are usually suppressed by presenting a single "best guess" or "reference case." The few key uncertainties chosen can be represented in the number and character of scenarios, depending on the intended use. A particular uncertainty might be represented by high and low values of some quantity, or by a reference case supplemented with high and/or low variants. If two or more uncertainties interact, they can be represented by scenarios that combine different outcomes of each: in the simplest form, two interacting

uncertainties can be represented by four scenarios, often illustrated by a two-by-two matrix.[28] Several alternative scenarios might seek to span a plausible range for some key quantitative variable, or present distinct qualitative outcomes for a single uncertainty, e.g., three types of competitive threat, or three political futures for a region in turmoil. Alternatively, scenarios can represent plausible extreme or "worst-case" scenarios, to assess the robustness of decisions or strategies.

How rich and complex should each scenario be? Defining scenarios as we have, as multivariate but synoptic, still leaves a wide range of levels of complexity to choose from. At one extreme, scenarios may specify time-paths for just a few quantitative variables, or even just one. Such scenarios are common, e.g., in applications such as analyzing a firm's profitability under alternative scenarios for oil prices, or projecting tax revenues under alternative scenarios of productivity growth and inflation, often in a standard "high, middle, low" format. A scenario can accommodate more complexity by projecting additional quantitative variables, but as the number of variables increases, so also does the need for an organizing principle or gestalt to tie them together in a non-arbitrary way.

At the other extreme, the core of a set of scenarios can be a set of rich, coherent narratives, an approach frequently called the Shell approach.[29] Each narrative, described principally in text, reflects a distinct conception of how the world might develop with a persuasive underlying causal logic. A narrative scenario can stand alone but may also include specifications of important quantitative variables, e.g., of population or economic growth, consistent with the broad causal logic underlying the scenario. The narrative provides the context and explanatory logic that tie together the time-paths of quantitative variables, although particular time-paths are regarded as illustrating, not defining, the scenario – i.e., a different scenario would present substantially different time-paths or relationships among them.

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[28]   Alternative interpretations of this matrix structure are discussed in van't Klooster and van Asselt 2006.

[29]   Van der Heijden 1996; Wack 1985a,b; Schwartz 1991; Shell International 2003.

The choice of how rich and complex to make scenarios has far-reaching implications for the process of developing the scenarios, what can be done with them, and the uses they can serve. The two extreme approaches imply large differences in how uncertainty is treated, what aspects of the problem receive attention, and the relationship between scenarios and their users, which we discuss for climate-change scenarios in Section 4. Richer and more complex scenarios require more time and effort to develop, whether based on quantitative models, narratives, or both. Complex, narrative-based scenarios may require many person-months of development to become realistic, relevant, and persuasive, with consistent relationships among scenario elements. In return for the extra effort, this approach allows great flexibility in the way potential futures are described. Narratives can convey different aspects of a future situation with varying degrees of salience or specificity, and they can compactly convey the tone or character of a future situation by allusion, where a precise specification would appear arbitrary or labored. The narrative approach avoids limiting the defining characteristics of a scenario to any particular set of pre-specified variables, but attempts to be alert to a wide range of potentially important characteristics and mechanisms of causal influence. Proponents of this approach argue that a coherent narrative at the core of a scenario is necessary to avoid arbitrariness in specifying multiple variables, and to make the exercise useful to decision-makers: "Most scenarios merely quantify alternative outcomes of obvious uncertainties (for example, the price of oil may be $20 or $40 a barrel in 1995). Such scenarios are not helpful to decision-makers".[30]

The remaining substantive choices in specifying a scenario follow from the preceding large-scale choices. They include specifying the time horizon and spatial extent of the scenarios, deciding the particular elements to include, and the temporal and spatial resolution at which scenario outputs are stated. Decisions about temporal resolution (e.g., hourly to multi-decadal) and spatial resolution (e.g., regional, national, continental scales) are particularly important when – as is often the case in global-change applications – scenarios are produced or used by quantitative models. Such models may have very precise requirements for the specification and resolution of inputs and outputs, creating the possibility for serious mismatches between what users need or expect, and what scenario developers feel comfortable and competent providing.

This section has discussed the uses, types, and characteristics of scenarios broadly, in any application area. The next section narrows the focus to climate change and related areas of global environmental change, summarizing the types of scenarios that have been used and proposed, and that might be required, to explore and inform decision-making in this area.

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[30]   Wack 1985a:74.