CHAPTER THREE

A Survey of Environmental Scenarios

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Contents

1. Introduction

"Scenario analysis has become a common and useful tool in many future-oriented environmental studies and assessments." So claims the Introduction of this book, as did the workshop held in 2002 upon which it is based. Although there still remain questions in some minds about its usefulness, a concept that is notoriously difficult to measure, the past five years have certainly reinforced the assertion of the commonality of scenario analysis for future-oriented environmental studies and assessments.

This chapter focuses on providing a survey of environmental scenarios and scenario exercises undertaken over the past few decades. Others, for example Swart et al. (2004), have more directly addressed the question of their usefulness. I begin by identifying what I mean by environmental scenarios in the context of this survey. This is followed by a discussion on a few ways in which to characterize scenarios,

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focusing on (1) the driving forces and key uncertainties explored, (2) the nature of the end states, i.e. the archetypes they reflect, and (3) the logic behind the scenarios and the scenario exercises, including their purpose, process, and substance. The value of doing so is to see the many ways in which scenario analysis has and can be used. After presenting a listing of key scenarios and scenario exercises, I conclude with some summary thoughts on the current state and future of environmental scenarios.

Please note that the listing of environmental scenarios provided here is necessarily incomplete. Even as I finalize this chapter in late 2007, I am discovering new exercises and am aware of forthcoming publications including the second OECD Environmental Outlook, a third Global Environmental Outlook for the Latin America and Caribbean region, the International Assessment of Agricultural Science and Technology for Development (http://www.agassessment.org/), and the Global Environmental Change and Food Systems (http://www.gecafs.org/index.html), all of which include some form of scenario analysis. The IPCC itself is also looking into stimulating the development of new scenarios (IISD, 2007). Thus, I apologize in advance for not including your favorite scenario exercise and would welcome further details on exercises not included.

2. Environmental and Environmentally-relevant Scenarios

2.1 Defining scenarios

It is important right away to define what is meant by a scenario and, more specifically, an environmental scenario. It is not the purpose here to provide definitive definitions, but rather simply to clarify how these terms are used in this chapter.

Alcamo and Henrichs in Chapter 2 of this book define a scenario as

> a description of how the future may unfold based on 'if-then' propositions and typically consists of a representation of an initial situation and a description of the key driving forces and changes that lead to a particular future state.

Numerous other definitions exist. A check of one dictionary[1] provides its primary meaning as "an outline of the plot of a dramatic or literary work." More relevant to its use here is the third definition provided, "an outline or model of an expected or supposed sequence of events." This is largely in agreement with the following definition taken from the United Nations Environment Programme's 3rd Global Environmental Outlook (GEO3):

> Scenarios are descriptions of journeys to possible futures. They reflect different assumptions about how current trends will unfold, how critical uncertainties will play out and what new factors will come into play (UNEP, 2002, p. 320).

[1] http://www.dictionary.com accessed on 03 December 2007. The original source for this definition is given as *The American Heritage® Dictionary of the English Language, Fourth Edition* Copyright ©2004 by Houghton Mifflin Company.

It is worthwhile to examine a few key points in this definition in more detail. Firstly, a scenario consists of not only the end-state (a future image or vision), but also the path by which this is achieved. Thus, it should be seen as a dynamic story and not simply a static snapshot of some future point in time. The latter may be more appropriately referred to as a vision. Visions can play an important role in developing scenarios, however. Specifically, scenarios can be developed in an exploratory fashion, i.e. the interim developments are not constrained by a predetermined end vision, or they can be developed in a backcasting fashion, i.e. the interim developments are driven in part by the desire to reach such a predetermined end vision. With the former, the key questions in the scenario development begin with *What if . . . ?*; in the latter *How could . . . ?* Many, if not most, scenario exercises combine both processes in an iterative fashion, but one approach generally takes precedence.[2] The end visions are also useful in characterizing different scenarios. We will return to this in a later section on scenario archetypes.

Secondly, this definition of a scenario implies a certain amount of 'completeness.' Specifically, this implies that the set of assumptions make up only part of the complete scenario. For example, if a time series of future population and economic growth figures are included as exogenous assumptions in a scenario exercise, it is somewhat improper and can be confusing to refer to these as population or economic growth scenarios, at least within the context of the specific scenario exercise. This can be particularly problematic when these figures are taken from another scenario exercise, which is often the case.

Another aspect of completeness is related to the question of to what extent specific actions are included in a scenario. These can be broadly divided into actions intended to cope with the situation portrayed in the scenario versus those that could fundamentally alter the nature of the scenario, in effect creating a different scenario.[3] If a scenario is to describe a particular journey, completeness would argue for fully incorporating the latter. Specifically such policies and behaviors should be part of the scenario and not left 'outside' in order to test their effect 'within' the scenario.

A third important point to make is that scenarios can be expressed in various forms. They can be presented with narrative text, images, tables and charts of data, maps, etc. The first two of these are primarily identified with what are called qualitative scenarios, and the latter with quantitative scenarios, often linked to computer models. Each of these has its particular strengths and weaknesses, and recent discussions have addressed the relationship between narratives and numbers in scenario development (see Chapter 6 of this book; Fontela, 2000; Alcamo, 2001; Swart et al., 2004). An important question in surveying scenarios related to this is whether each run of a model should be considered a separate scenario. For this survey, we have focused on scenarios that go beyond simple model runs, but as will be seen, we have chosen to include a discussion of some models as they have played an important role in the history of environmental scenarios.

[2] Robinson (2003) presents an interesting exploration of the iterative nature of some scenario exercises and, in the process, introduces of the concept of second-order backcasting.

[3] This division will obviously differ depending upon the perspective of a particular actor. 'Smaller' actors, i.e. those with less influence over the key determinants of a scenario, will perceive most actions under their control as falling into the former category, whereas 'bigger' actors may see the opposite. We do recognize that the determinants of a specific scenario may reflect the accumulated effects of a number of 'smaller' actors, somewhat blurring the distinction.

Finally, perhaps the most important thing to note is that scenarios are not meant to be predictive. The following quote, also from GEO3, is broadly reflective of the presumption of most recent scenario studies:

> *It is now generally accepted that scenarios do not predict. Rather, they paint pictures of possible futures and explore the differing outcomes that might result if basic assumptions are changed (UNEP, 2002, p. 320).*

Following Robinson (2003), scenarios at best include conditional projections in that particular outcomes are 'predicted' subject to the basic assumptions made. It is generally recognized that there will always be uncertainty around the particular assumptions. This has lead many to call for the use of multiple baselines (Hourcade and Robinson, 1996). There do remain studies that use a single baseline, but these are more often treated as reference cases against which to compare the impacts of different assumptions, particularly about policy choices, and not as a projection of a most likely future as might have been the case in the past. At the same time, the use of multiple baselines has engendered a debate over whether it is possible to apply (subjective) probabilities to these different baselines (Schneider, 2002; Dessai and Hulme, 2004; Yohe et al., 2005).

2.2 Defining environmental scenarios

Turning our attention from scenarios in general to the notion of environmental scenarios, an obvious question arises – what makes a scenario an environmental scenario? A simple answer is that a scenario is an environmental scenario if a key focus is some aspect of the environment. This is reflected in the guidelines in Chapter 1 of this book where Alcamo presents the following description of environmental scenario analysis:

> *Environmental scenario analysis has been used to examine many different scales and types of problems ranging from global sustainability to very specific environmental issues such as changes in emissions, air quality, or land cover in a specific district or region.*

This leaves open a rather wide range of scenarios to be considered as environmental scenarios. There is no restriction on spatial or temporal scales. There is also a certain amount of freedom in defining what are 'environmental' issues, though there is some general agreement as to what these are. To be considered an environmental scenario, one or more of these issues should be dealt with in the scenario. An important consideration here is that many policies and actions may have significant implications for the environment, even if they are not what are normally considered environmental policies and actions. These environmentally-relevant *policies and actions* should not be ignored in developing environmental scenarios. Other scenarios, which do not have a primary focus on an environmental issue, may be considered environmentally-relevant *scenarios* if they provide information that can be made use of in providing the overall context and important assumptions for environmental scenarios or even just environmental policy debates (see Berkhout and Hertin,

2002).[4] This distinction can get quite hazy as more scenarios begin to address issues of sustainability (Swart et al., 2004).

3. Characterizing Scenarios

There are almost as many ways to characterize scenarios and scenario exercises as there are definitions of scenarios. Perhaps most commonly, they are distinguished by the why and how of the scenario exercises, i.e. their purpose and process of development. Some reviewers prefer to focus more specifically on the content of the scenarios, notably the driving forces and key uncertainties explored. Others have chosen to differentiate them by the nature of the end states, what I will call the archetypes specific scenarios reflect.[5] Finally, scenarios can be distinguished by their subject matter. In this section, I will discuss the first three of these ways of characterizing scenarios, and present the fourth later in this chapter.

3.1 Scenario logic – purpose, process, & substance

Various authors – most recently Westhoek et al. (2006), Börjeson et al. (2006), and Bishop et al. (2007) – have explored scenario types and techniques. Here, I draw upon van Notten et al.'s (2003) scenario typology. Their typology examines 14 separate characteristics of scenarios, but these are aggregated into three overarching themes: (1) project goal, (2) process design, and (3) scenario content.[6] In very simple terms, these can be stated as the (1) why?, (2) how?, and (3) what? of scenarios and scenario exercises. As might be expected, there can be strong connections between these themes. The project goal influences the process design that, in turn, influences the scenario content.

The first theme addresses a scenario analysis' objectives as well as the subsequent demands on the design of the scenario development process. On the one end of the spectrum is the goal of exploration. This might include awareness raising, the stimulation of creative thinking, and gaining insight into the way societal processes influence one another. In such an exercise, the process is often as important as the product; the product – the scenario or set of scenarios – may even be discarded at the end of the process. At the other end of the spectrum is the goal of decision support. The scenarios might propose concrete strategic options. Decision-support scenario exercises often contain value-laden combinations of scenarios that are described as desirable, middle-of-the-road and undesirable scenarios. The two types of project goals can be combined. In a first phase, scenarios are developed in an exploratory fashion, after which new scenarios are developed by zooming in on aspects relevant to strategy development.

[4] This may also work in reverse as scenarios with an original focus on environmental issues are used to address broader non-environmental issues (see for example Eames and Skea, 2002).

[5] Westhoek et al. (2006) use the term archetype to refer to the purpose of a scenario exercise.

[6] As explained below, content refers to the range of issues included in the exercise, not to any specific issue.

Process design, the second overarching theme, focuses on how scenarios are produced. It addresses aspects such as the degree of quantitative and qualitative data used, or the choice for stakeholder workshops, expert interviews, or desk research. On the one end of the dimension there is the intuitive approach, which considers scenario development almost as an art form and leans heavily on qualitative knowledge and insights. Creative techniques such as the development of stories or storylines are typical intuitive approaches to scenario analysis. Interactive group sessions with a high variety of people are often central to storyline development. At the other end of the dimension is the formal approach. Contrary to the intuitive approach, the formal school regards scenario development primarily as a rational and analytical exercise. The formal school tends to work from quantified knowledge and often relies on computer models in developing scenarios. As noted previously, both approaches have their strengths and a number of recent studies have worked to combine the two approaches (see e.g. UNEP, 2002, 2007; MA, 2005; IPCC, 2000, and Rijsberman, 2000).

The third theme, scenario content, looks at the composition of the developed scenarios. This theme focuses on the nature of variables and dynamics in a scenario, and how they interconnect, and is similar to an analysis of the scenario dimensions discussed below. With regard to scenario content van Notten et al. (2003) distinguish between complex and simple scenarios. A multitude of interpretations of the term "complex" exists. Applied to the context of scenario analysis, a complex scenario is one that is composed of an intricate web of causally related, interwoven, and elaborately arranged variables and dynamics. Complex scenarios manifest alternative patterns of development consisting of a series of action-reaction mechanisms. They often draw on a broad range of actors, factors, and sectors, and use multiple time or spatial scales. In contrast, simple scenarios are more limited in scope. A simple scenario might focus on a single topic, considering only the immediate or first-order effects of changes in the external environment. Simple scenarios may also limit themselves to the extrapolation of trends. The term simple is not meant to indicate poor quality. A scenario analysis with a narrow focus or a short-term perspective may not require the relatively lengthy and demanding undertaking of developing complex scenarios, which can be a benefit in many circumstances. Furthermore, a simple scenario can be more effective in communicating its message than a complex scenario.

3.2 Dimensions – driving forces and key uncertainties

As noted in the definition used in this chapter, scenarios reflect different assumptions about how current trends will unfold, how critical uncertainties will play out, and what new factors will come into play. Driving forces represent key factors, trends or processes that influence the situation, focal issue, or decisions, and propel the system forward and determine the story's outcome. These may or may not be invariant over time. Whether they are or are not can represent critical uncertainties, which reflect important factors or processes that have an important role in determining the unfolding of the scenarios and whose values or outcomes are very difficult to anticipate.

The most common driving forces considered in scenario studies can be grouped into demographic, economic, social, scientific and technological, institutional, cultural, and environmental. Population size, rate of change, distribution, age structure and migration are all critical aspects of demography. Economic assumptions, often simply given as growth rates, can also include aspects such as production, finance and the distribution of resources both between regions and across sectors of society. Social factors reflect aspects of human development such as health, education, security, identity and freedom, which are all clearly related to economic development, yet go well beyond it. Assumptions about the future of science and technology, both their rate of development and accessibility are key, as these continue to transform the structure of production, the nature of work, and the use of leisure time. Institutional assumptions refer to actions, processes, traditions and institutions by which authority is exercised. It is most often associated with formal governmental bodies, but this need not be the case. Private institutions, such as corporations and nongovernmental organizations, also play important roles. Culture includes the set of values and institutions that enables a society, or any other group, to develop and maintain its identity. Finally, the environment is included as a driving force because it is more than a passive receptacle for change. Just as the assumptions about human and societal behavior shape scenarios, so do the assumptions about the behavior of environmental systems. For example, it can make a significant difference in a scenario whether it is assumed that climate sensitivity, the equilibrium change in global average surface temperature due to a doubling of the carbon dioxide concentration in the atmosphere, is actually towards the lower or higher end of the range of scientific uncertainty.

Not all scenario exercises consider all of these driving forces, explicitly or implicitly, and scenarios differ in the depth to which they are addressed. These differences can be significant and can play a role in classifying different scenarios. This is reminiscent of the notion of the composition of scenarios discussed above.

One common method of scenario development begins by specifying explicitly early on those driving forces and critical uncertainties of principal interest. These are summarized in two axes, with the 'extremes' of each axis representing one end of the assumptions. These dimensions can be as simple as high vs. low economic growth and high vs. low population growth, but they can be much richer, reflecting amalgamations of more than one driving force. The resulting four quadrants provide the framework for the further development of four distinct scenarios. This technique is often referred to as a deductive approach (van der Heijden, 1996).[7] One of the best-known examples in the environmental field is the IPCC SRES framework shown in Figure 3.1. The two axes are the degree to which the world becomes more globally integrated vis à vis remaining more regionally focused and the degree to which economic vis à vis social and environmental considerations drive decision-making (IPCC, 2000). The global scenarios of the Millennium Ecosystem Assessment (MA, 2005) settled on a similar approach, but with the second axis emphasizing the degree to which actions to address ecosystem degradation is proactive or reactive.

[7] Bishop et al. (2007) refer to this as the Royal Dutch Shell/Global Business Network matrix approach. van 't Klooster and van Asselt (2006) present an interesting ethnographic analysis of how the approach is applied in practice.

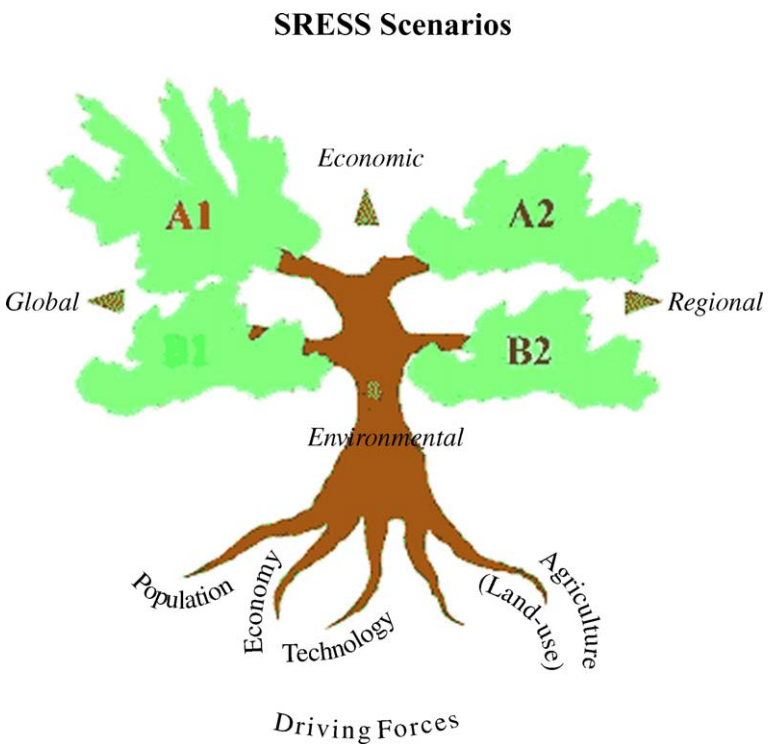

Figure 3.1 The SRES scenario framework. *Source: IPCC, 2000, p. 71.*

Alternatively, a more inductive approach can be followed in which driving forces and critical uncertainties are not specified explicitly early on and only general statements are made in order to get the scenario process started. These can either be statements about initial trends, certain events along the way, or the end state. During the actual development, the assumptions are, hopefully, made clearer and more explicit. The development of the GEO3 (UNEP, 2002) and GEO4 (Rothman et al., 2007) scenarios more closely followed this latter approach.

The deductive approach can be seen as stifling creativity, but it does ensure a certain amount of completeness in the range of scenarios considered, at least with respect to the chosen dimensions. Furthermore, it can be easier to communicate to those not involved in the development process. On the other hand, the inductive approach may allow for a wider range of scenarios to be developed.[8]

It is important to note that developments arising from each of the driving forces and resolutions of the key uncertainties may not unfold in isolation from one another. Rotmans and de Vries (1997) used packages of assumptions about driving forces and critical uncertainties, which were coherent following notions drawn from cultural theory (see e.g. Thompson et al., 1990). Rothman et al. (2007) worked to

[8] Here wider refers to the range of different fundamental uncertainties considered, not the actual number of scenarios. For example in GEO-3&4, as in the IPCC SRES and MA, four scenarios were developed.

ensure coherence by explicitly posing a series of questions related to each of the driving forces. Most other studies have checked for coherence less formally, if at all, and this remains one of the most criticized aspects of many scenario studies. This may pose a more significant problem for the deductive approach in that the plausibility of scenarios in each of the four quadrants implies that the dimensions are independent, i.e. knowing something about how one the driving forces and critical uncertainties in one dimension will play out in the future does not tell you anything about those in the other dimension. In any case, being aware of consistency can also help to identify points where surprises or discontinuities can be expected to occur. If current trends for driving forces come near to recognized physical or social boundaries, then something will have to give; these points can be the site of some of the most interesting developments in any scenario.

3.3 Archetypes – end states

There have been various attempts to categorize scenarios in terms of the general nature of the future that they portray, reflecting both the assumptions about trends, uncertainties, and new factors, as well as the end visions that are depicted. The goal has been to identify particular archetypes within which, hopefully, most scenarios can be classified. This section presents a few of these typologies.

Oftentimes these archetypes have a normative character to them, e.g. scenarios are considered as explicitly positive or negative, but this is not necessarily the case. In fact, business-as-usual, or one of its variants, is one common archetype. The archetypes are often used to guide the development of scenarios. This is obvious for scenarios developed using backcasting, but can be true even when they are developed in an exploratory fashion. This is done by making assumptions such that the scenario is naturally driven in a particular direction. For example, a scenario with a focus on the role of ecosystem goods and services in providing human well-being can be completely exploratory in nature, but begin with the assumptions that, within the range of current scientific uncertainty, climate systems will change rapidly in the presence of small changes in atmospheric composition, natural systems are very fragile to small changes in climate, ecosystem goods and services are not easily substituted by human made capital, and human society is not readily adaptable.

From its outset, the Global Scenarios Group (GSG) has used a set of archetypes to help define its scenarios (Gallopin et al., 1997; Raskin et al., 1998, 2002). These are shown in Table 3.1 and reflect distinct assumptions about individual and societal approaches to social and environmental challenges. As shown, they explicitly root these in worldviews or myths defined by different schools of thought throughout history. For completeness, they include the category of 'Muddling Through,' to which they ascribe "the passive majority on the grand question of the global future" (Raskin et al., 2002, p. 19).

In their review of the Global Futures Scenarios, Morita et al. (2001) examined a number of demographic, socio-economic, technological, and environmental dimensions in an attempt to group the existing scenarios. They eventually clustered them based upon whether general conditions deteriorate, stay basically the same, or improve, with the latter category subdivided based on the relative importance of

Table 3.1 The scenario archetypes of the global scenario group

Worldview	Antecedents	Philosophy	Motto
Conventional worlds			
Market	Smith	Market optimism Hidden & enlightened hand	Don't worry, be happy
Policy reform	Keynes Brundtland	Policy stewardship	Growth, environment, equity through better technology, and management
Barbarization			
Breakdown	Malthus	Existential gloom, popula-tion/resource catastrophe	The end is coming
Fortress world	Hobbes	Social chaos, nasty nature of man	Order through strong leaders
Great transitions			
Eco-communalism	Morris, Social utopians	Pastoral romance; human goodness; evil of industrialism	Small is beautiful
New sustainability paradigm	Mill	Sustainability as progressive global social evolution	Human solidarity, art of living
Muddling through	Your brother-in-law (probably)	No grand philosophers	Que sera, sera

Source: Raskin et al., 2002.

technology versus other factors. As Table 3.2 shows, even this seemingly simplistic typology still yields an interesting set of archetypes, especially when the subgroups are considered.

Van Asselt et al. (1998) categorized scenarios according to their main binding element: (1) high economic growth, "Money Maker," (2) environmental protection, "Think Green," (3) limited policy action, "Wait and See," and (4) a pessimistic fu-

Table 3.2 Scenario archetypes from the IPCC (Morita et al., 2001)

Scenario group	Scenario subgroups	Number of scenarios
1. Pessimistic scenarios	*Breakdown:* collapse of human society	5
	Fractured world: deterioration into antagonistic regional blocs	9
	Chaos: instability and disorder	4
	Conservative: world economic crash is succeeded by conservative and risk-averse regime	2
2. Current trends scenarios	*Conventional:* no significant change from current and/or continuation of present-day trends	12
	High growth: government facilitates business, leading to prosperity	14
	Asia Shift: economic power shifts from the West to Asia	5
	Economy Paramount: emphasis on economic values leads to deterioration in social and environmental conditions	9
3. High-tech optimist scenarios	*Cybertopia:* information & communication technologies facilitate individualistic, diverse and innovative world	16
	Technotopia: technology solves all or most of humanity's problems	5
4. Sustainable development scenarios	*Our common future*: increased economic activity is made to be consistent with improved equity and environmental quality	21
	Low consumption: conscious shift from consumerism	16

ture outlook, "Doom Monger" (see Figure 3.2). Similar to Morita et al. (2001), they find that even when scenarios are similar in one characteristic, they can differ substantially in others. However, because of the different purpose of their review (which was to find potential archetypes for the development of new scenarios rather than dividing the clusters into subgroups) they made choices about some of these 'sub'-characteristics in order to create 'enriched' archetypes.

A fourth set of archetypes is provided by Wilson (1999). He reviewed a relatively limited set of scenarios (fewer than 10 sets), but was able to distill four broad scenario outlines. He names these: (1) Market Dominance, (2) Global Institutional

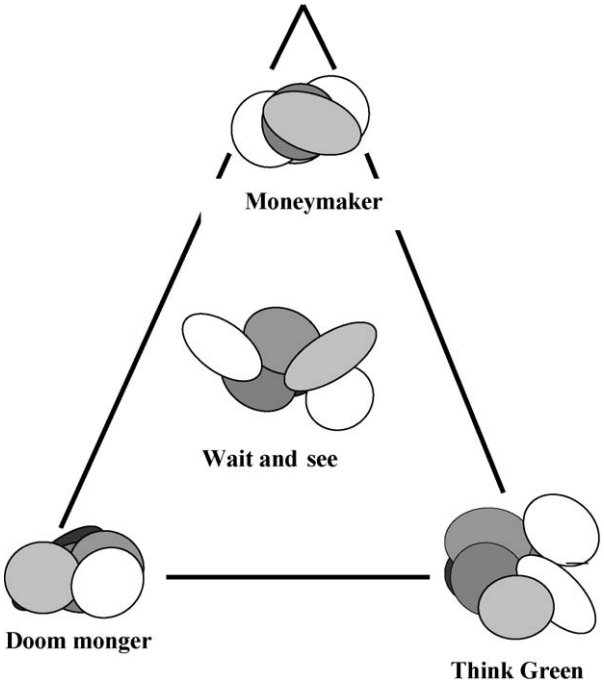

Figure 3.2 van Asselt et al.'s scenario archetypes. *Source: van Asselt et al., 1998, p. 82.*

Governance, (3) Fortress against the Storms, and (4) People Power. Two things are of particular interest about Wilson's classification. First, they closely match four of the archetypes within the GSG scheme (Market, Policy Reform, Fortress World, and New Sustainability Paradigm). Secondly, he highlights a period of turbulence that must be passed through on the way to either the Fortress against the Storms or People Power. This introduction of a dynamic element in his typology of archetypes is not seen as explicitly in the previously mentioned typologies.

This is, however, seen in Tibbs (1999, p. 35), who draws explicitly from popular literature and current concerns about unsustainability to present a "scenario family tree" of what he considers possible, if not plausible futures (see Figure 3.3). Whereas a number of archetypes identified here can be matched with those in the other schemes, e.g. "Policy Utopia" with "Policy Reform" in Raskin et al.'s scheme and "Our Common Future" in Morita et al.'s, Tibbs' depiction adds an important dynamic aspect not seen in most of the others. Specifically, it shows more clearly how the different archetypes are related and even how the future may need to pass through one phase before reaching another. For example, "The Far Side," which resembles the two different Great Transitions scenarios in the GSG's format, only occurs after passing through a period of "Gaia Strikes Back." Irrespective of whether any of the specific paths that can be traced in Tibbs' figure makes sense, his approach provides a rich picture of potential futures.

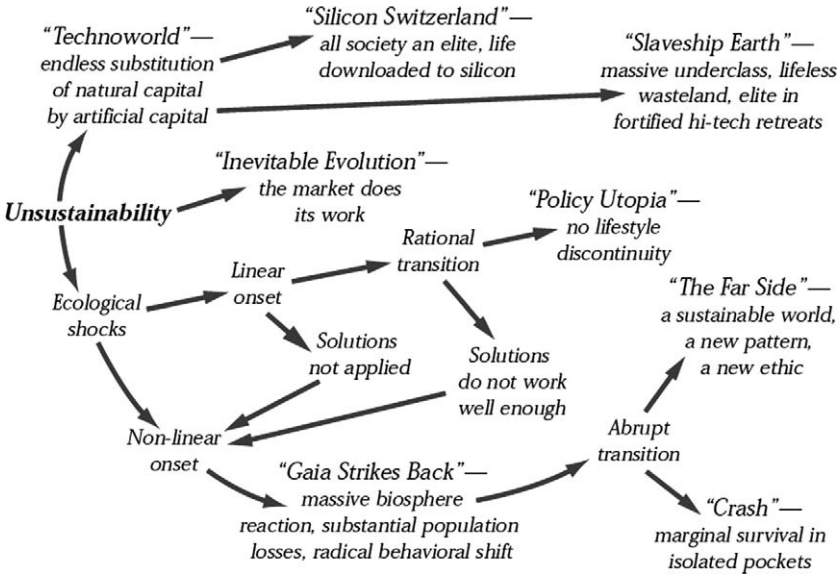

Figure 3.3 Tibbs' scenario archetypes. *Source: Tibbs, 1999, p. 35.*

4. Existing Surveys

This survey does not stand alone, but rather draws from and builds upon a number of other reviews of scenarios, environmental and otherwise, that are briefly described in this section. The interested reader is encouraged to also consider these other reviews, as each has a different focus and highlights different aspects of many of the same scenarios.

In the 1980s and early 1990s, several persons involved in the development of the original global models, which were used to develop some of the earliest environmental scenarios, reflected upon the state of the art at the time. Of particular note are those done by Meadows et al. (1982) and Hughes (1985). Bloomfield (1986) and Brecke (1990, 1994), who were not involved in these modeling efforts, also provide interesting reviews.

Today, there are several groups that maintain scenario databases. Among the most significant are as follows:

- The European Environment Agency maintains an Information Portal for Environmental Scenarios (http://scenarios.ew.eea.europa.eu/). This includes links to environmental outlooks and scenario studies. These are distinguished by their specific focus, that is on a geographic region, a specific environmental issue, or economic sector.
- Since 1997, the Millennium Project of the American Council of the United Nations University has maintained an annotated scenario bibliography, which now contains more than 700 scenarios (Glenn and Gordon, 2007; see also their

website at http://www.millennium-project.org/). These are divided into 7 categories as follows: (1) International Economics and Wealth, (2) Environmental Change and Diversity, (3) Technological Capacity, (4) Demographics and Human Resources, (5) Governance and Conflict, (6) Regions and Nations, and (7) Integration or Whole Futures.

- The OECD International Futures Programme, established in 1990, maintains a database of information related to futures studies, including scenario studies (see their website at http://www.oecd.org/department/0,3355,en_2649_33707_1_1_1_1_1,00.html).
- In developing its most recent set of emissions scenarios (SRES), the Intergovernmental Panel on Climate Change (IPCC) undertook an extensive review of existing emission scenarios. This was first presented in Nakicenovic et al. (1998) and has subsequently been updated to include the official SRES and post-SRES scenarios, along with other emissions scenarios. The most recent version of this database, version 3, contains 909 scenarios from 285 sources and is maintained by the Center for Global Environmental Research of the Japanese National Institute for Environmental Studies (available at http://www-cger.nies.go.jp/scenario/, see also Hanaoka et al., 2006). For the IPCC's Third Assessment Report, Morita et al. (2001) also constructed a Global Futures Scenarios Database containing 124 scenarios from 48 sources. These were restricted to scenarios that were "global, long-term, and multidimensional in scope" and with only a few exceptions were primarily narrative scenarios (Morita et al., 2001, p. 137). A wide range of climate related scenarios are also reviewed in the Fourth Assessment Report (see Carter et al., 2007; Christensen et al., 2007; Fisher et al., 2007; Meehl et al., 2007).

A few other surveys also deserve mention. Hertin et al. (1999) reviewed the relevant climate impacts and futures related literature as part of the UK Foresight process. In the early stages of the European VISIONS project (Rotmans et al., 2000), van Asselt et al. (1998) undertook a review of recent European scenario studies. This was later picked up and expanded at the request of the European Environment Agency (Greeuw et al., 2000). Finally, as part of the UNEP GEO process, Raskin produced a review of regional scenarios for environmental sustainability (Raskin, 2000) and later a review of global scenarios for the Millennium Ecosystem Assessment (Raskin, 2005). The US Climate Change Science Program released a review of global change scenarios as a companion piece to its development of new scenarios of greenhouse gas emissions and concentration (Parson et al., 2007). Zurek (2006) has reviewed global scenarios from a food systems perspective for the Global Environmental Change and Food Systems (GECAFS) project, and Alcamo et al. review land use scenarios in Chapter 4 of this book. Finally, the EEA (2007a) has summarized a wide range of future oriented studies of interest to the European region.

5. Overview of Environmental Scenarios

So, what environmental scenarios are out there? As noted in the Introduction, it is beyond the scope of this chapter to try to present a comprehensive list of environmental and environmentally-relevant scenarios. Beyond the sheer numbers, many scenario exercises are not fully documented or documentation is not easily accessible. Others are ongoing and therefore information is limited at this time. It must be said, though, that more and more exercises are making use of modern technologies such as the Internet, which means that information on many scenarios and scenario exercises is more widely available than in the past.

I have made the choice to divide the scenarios and scenario exercises presented here into two broad categories. The first are exercises that have focused on a specific environmentally significant topic, e.g. energy, climate, water, food, or land use. Since these issues are interrelated, not only with each other but also other factors, there can be some fuzziness in the boundaries between these exercises. Most, however, do have a clear emphasis. The second category consists of exercises that I broadly refer to as integrated scenarios. These attempt to address jointly a number of interrelated issues, usually at a particular geographic scale. Thus, I have sub-divided these by level, i.e. global, regional, and country and lower levels. Finally, a number of outlook studies, e.g. the Asian Environment Outlooks (ADB, 2001, 2005) might suggest that they include scenarios, but not in the way that meets the criteria set out here. Therefore, they are not listed.

5.1 Topical scenarios

Earlier I defined an environmental scenario as one that has the environment as a key theme. Defined broadly, this can include scenarios that emphasize the driving forces of environmental change, the changes themselves, or the impacts of and responses to these changes. I have deliberately excluded economic and population scenarios that are not part of a broader environmental scenario study. As noted above, though, these are often used as inputs to environmental scenario studies. A review of the literature does show a general clustering of the scenarios around a few general topics. Paralleling the 4 elements of ancient Greece, I classify these as earth (land use and agriculture), air (climate and air pollution), fire (energy), and water (water). In addition to these there are scenarios of other environmental issues: such as biodiversity, biotechnology, and global chemical cycles. Obviously, a number of these issues are intertwined and overlap in various scenario studies, but have a primary emphasis that can usually be defined. In this section, I have also emphasized scenarios that take a global or large regional perspective, with some exceptions for climate impact scenarios that have drawn heavily from global climate scenarios. A number of scenarios focusing on specific topics have been developed for individual regions, but these are not considered here.

5.1.1 Land use and agriculture

Land use and land use change are strongly related to other environmental issues. They can be viewed as key driving forces for other changes, as impacts from other

changes, or both. Thus, most scenarios of land-use change are embedded in other scenario studies, particularly those looking at climate, food, and biodiversity. More recently, though, scenarios have begun to appear with land use as a primary focus.

- UNU/WIDER Forest Transition and Carbon Fluxes (Palo, 1999).
- EURURALIS and ATEAM (Klijn et al., 2004; Verburg et al., 2006).
- ACCELERATES (Rounsevell et al., 2006).
- Urban Land Use (Reginster and Rounsevell, 2006).
- Scenarios on the Territorial Future of Europe (ESPON Project 3.2, 2007).
- PRELUDE (EEA, 2007b).

A review of land use scenarios is also presented by Alcamo et al. as Chapter 6 of this book.

Food has been an issue of regional and global concern for many years. The Food and Agricultural Organization of the UN and the International Food Policy Research Institute have produced scenarios of supply and demand for the next few decades. In addition, IFPRI and the International Water Management Institute (IWMI) have also produced a separate scenario study, linked to the World Water Visions noted below, illustrating the close links between the different environmental issues. Finally, the International Assessment of Agricultural Science and Technology for Development (http://www.agassessment.org/) and Global Environmental Change and Food Systems (http://www.gecafs.org/index.html) are advancing the use of scenarios in this area. These scenarios are included in the following publications:

- FAO Toward 2010, Toward 2015/30 (Alexandratos, 1995; Bruinsma, 2003).
- IFPRI 2020 Vision (Rosegrant et al., 2001).
- World Water and Food to 2025 (Rosegrant et al., 2002).

5.1.2 Climate (and air pollution)

Concerns about climate change have not only boosted the use of environmental scenarios, but have in many ways sparked the resurgence of large-scale environmental modeling. Some of the scenarios have focused on the key pressures leading to climate changes, i.e. emissions of greenhouse gases from energy use, industrial processes, and land-use change. Others have focused on the actual changes in the climate system as a result of these changing pressures. Still others have emphasized the impacts of climate changes on natural and human systems. Finally, a few integrated assessment studies and models have attempted to incorporate all of these aspects. The following represent only a partial list of recent climate scenarios.[9] More recently, as represented by the FinSken and Air-Clim projects, there have been attempts to produce scenarios that integrate climate changes with other air pollution issues.

- IPCC 1992 scenarios of climate drivers (IPCC, 1992).
- IPCC pre and post-SRES – scenarios of climate drivers (Alcamo and Nakicenovic, 1998; Morita, 2000; IPCC, 2000; Morita et al., 2001; Fisher et al., 2007).

[9] With the exception of the IPCC (1992) scenarios, we have focused on the most recent climate scenarios. The exception was made to reflect the continuing importance of these scenarios.

- IPCC WGI – scenarios of climate changes (Christensen et al., 2007; Meehl et al., 2007).
- IPCC WGII – scenarios for impacts and adaptation (Carter et al., 2007).
- US Climate Change Science Program (Clarke et al., 2007).
- ACACIA (Parry, 2000).
- UK (Hulme et al., 2002).
- US (National Assessment Synthesis Team, 2000).
- Canada (Environment Canada, 1998).
- Finland FinSken: Developing Consistent Global Change Scenarios for Finland.
- Air-Clim (Alcamo, 2002).

5.1.3 Energy

Spurred on, in part, by the oil crises of the 1970s, energy has been a primary focus of many scenario exercises. As concerns have shifted from the depletion of energy resources to the environmental impacts of energy use, these have become more closely intertwined with the issues of climate change and regional air pollution. Thus, a number of the climate related scenario studies noted above do include embedded energy scenarios. Still, a number of scenario exercises clearly place their emphasis on energy supply and demand. A few of the most recent exercises looking at these issues at a global level are listed below.

- International Energy Agency World Energy Outlooks (e.g. International Energy Agency, 2006).
- International Institute for Applied Systems Analysis and World Energy Council Global Energy Perspectives (Nakicenovic et al., 1998; UNDP, 2000).
- World Energy Council Energy Policy Scenarios (WEC, 2007).
- Shell Energy Scenarios (Shell International, 2001).
- World Business Council for Sustainable Development (WBCSD, 1999).
- CPB's Four Futures for Energy Markets and Climate Change (Bollen et al., 2004).

5.1.4 Water

Although it is inherently a local issue, there have been a few recent efforts to look at water demand and supply from a global perspective. Two of these are cited below. The first of these was prepared by the World Commission on Water for the 21st Century and presented at the Second World Water Forum in March 2000 in The Hague, the Netherlands. The latter is currently ongoing and will produce a global 'water scenario' based on megaregional and subregional scenarios.

- World Water Visions (Gallopin and Rijsberman, 2000; Alcamo et al., 2000; Rijsberman, 2000, see also the website at http://www.worldwatercouncil.org/vision.shtml).
- Global International Water Assessment (http://www.giwa.net/).
- WBCSD Water Scenarios to 2025 (WBCSD, 2006).
- Comprehensive Assessment of Water in Agriculture (Molden, 2007).

5.1.5 Other

Finally, there have been scenario studies on topics not covered by the preceding subjects.

- Biotechnology (WBCSD, 2000; Sager, 2001).
- Nitrogen inputs to coastal ecosystems (Seitzinger et al., 2002).
- Biodiversity (Sala et al., 2000; Chapin et al., 2001, see also the scenario work of the Millennium Assessment at http://www.millenniumassessment.org/). These scenarios have made extensive use of other topical scenarios.
- AIDS in Africa: Three Scenarios to 2025 (UNAIDS, 2005).
- Transportation (WBCSD, 2004).

5.2 Integrative scenarios

The scenario studies presented in this section begin with a particular geographic focus. They are integrated in that they address a number of interrelated issues. We have focused here on those studies for which the environment is either the central focus or one of the primary foci.

5.2.1 Global

Many, if not most, of the global integrated scenarios are rooted in the tradition of global modeling that had its start in the early 1970s. Meadows et al. (1982), Hughes (1985), and Brecke (1990, 1994) provide reviews of a number of these models, exploring their strengths, weaknesses, similarities, and differences. Each of these models has been used in various studies to produce different global scenarios with important environmental aspects. A short list of these models is provided below. For a more complete bibliography of studies using these models, the user is referred to Brecke (1990).

- World2, World3 (Meadows et al., 1972; Meadows et al., 1991; Meadows et al., 2004).
- Latin American World Model Bariloche Group (Bruckmann, 1974; Herrera et al., 1976).
- Soviet Global Model (SIM/GDP) (Brecke, 1995).
- Future of Global Interdependence (FUGI) (Kaya et al., 1983, cited in Brecke, 1990).
- Generating Long-term Options By Using Simulation (GLOBUS) (Bremer, 1987, cited in Brecke, 1990).
- Systems Analysis Research Unit Model (SARUM) (Systems Analysis Research Unit, 1977, cited in Brecke, 1990).
- World Input–Output Model (Leontief et al., 1977).
- World Integrated Model (Mesarovic and Pestel, 1974; Hughes, 1980).

There have also been more recent global scenario efforts. Some of these evolved directly from earlier modeling efforts; others represent newer endeavors that were nevertheless inspired by the earlier work. A few of these are listed below. As with the earlier models, these have been used in various scenario studies, including some of those mentioned in other parts of this survey.

- "The Future of the Environment" (Duchin and Lange, 1994), evolved from WIOM.
- International Futures (Hughes and Hillebrand, 2006), evolved from WIM.
- Tool to Assess Regional and Global Environmental Targets (TARGETS) (Rotmans and de Vries, 1997).
- Integrated Model to Assess the Global Environment (IMAGE 2) (Alcamo et al., 1998; Bouwman et al., 2006).
- Asia-Pacific Integrated Model (AIM) (Kainuma et al., 2003).

Finally, there have been a number of exercises that have developed globally integrated scenarios independent of any specific model. These scenarios all include storylines and some consist of both storylines and quantitative scenarios generated from various models. Documentation of the scenarios ranges from short articles to book-length reports.

- Scenarios of the Global Scenario Group (Gallopin et al., 1997; Hammond, 1998; Raskin et al., 1998; Raskin et al., 2002; see also their website at http://www.gsg.org/).
- United Nations Environment Programme GEO3 (UNEP, 2002) and GEO4 (Rothman et al., 2007) scenarios.
- Millennium Ecosystem Assessment global scenarios (Carpenter et al., 2005).
- US National Intelligence Council Scenarios (US NIC, 2004).
- Scenarios of the Chatham House Forum (Royal Institute of International Affairs, 1998, see also their website at http://www.chforum.org/).
- Scenarios of the Millennium Project (Glenn and Gordon, 1998) see also their website at http://www.acunu.org/).
- "Global Scenarios to 2025" (van der Veer, 2005).
- "Earth at a Crossroads" (Bossel, 1998).
- "Surprising Futures" (Svedin and Aniansson, 1987).
- "Scenarios for Socioeconomic Development" (Tóth et al., 1989).
- "Exploring Sustainable Development" (WBCSD, 1997).
- "Visions of Alternative (Unpredictable) Futures" (Costanza, 2000).
- "Global Scenarios for the Millennium" (Tibbs, 1998).

5.2.2 Regional

The regional level studies cited below show an interesting geographic mix. The regions that have received the most attention, at least in terms of integrated scenario studies, are Africa and Europe. The reasons for this are quite different, however. In Africa, it is likely that this is due to general concerns about the environment and its link to development. In Europe, it is probably more related to the ever-strengthening political and economic ties between countries.

Africa

- Africa 2025: What Possible Futures for Sub-Saharan Africa (Sall, 2003).
- African Environmental Outlook and African Environmental Outlook 2 (UNEP and African Ministerial Conference on Environment, 2002, 2006).

- Southern Africa Beyond the Millennium: Environmental trends and scenarios to 2015 (Dalal-Clayton, 1997).
- Toward Environmentally Sustainable Development in Sub-Saharan Africa: A World Bank agenda (World Bank, 1996).
- Preparing for the Future: A Vision of West Africa in the Year 2020 (OECD, 1995, cited in Raskin, 2000).
- The State of the Environment in Southern Africa (SARDC, 1994, cited in Raskin, 2000).
- Beyond Hunger in Africa: Conventional wisdom and a vision of Africa in 2057 (Achebe et al., 1990).
- Futures for the Mediterranean Basin – The Blue Plan (Grenon and Batisse, 1989, cited in Raskin, 2000).
- Sub-Saharan Africa – From Crisis to Sustainable Growth (World Bank, 1989, cited in Raskin, 2000).

OECD

- OECD Environmental Outlook (OECD, 2001, 2008).

Europe

- Institute for Prospective Technology Studies Futures Project (IPTS, 2000).
- VISIONS (Rotmans et al., 2000; van Asselt et al., 2005).
- Environment in the European Union at the Turn of the Century (European Environment Agency, 1999).
- Europe 2010 (Betrand et al., 1999).
- Future Environments for Europe (Stigliani et al., 1989).
- Air-Clim (Alcamo, 2002).
- Four Futures for Europe (de Mooij and Tang, 2004).

Latin America

- GEO Latin America and the Caribbean 2003 (UNEP, 2004) (a new version is to be published in 2008).
- Ecological prospective for Tropical Latin America (Gallopin and Winograd, 1995, cited in Raskin, 2000).

5.2.3 Studies of countries and smaller geographic areas

Finally, a number of studies have been undertaken at the country or more local level. Several were initiated as part of the sub-global assessments of the Millennium Ecosystem Assessment (Lebel et al., 2005) and continue to this day. Many, if not most, are parts of larger scenario exercises, of which environment is only one component, but still provide valuable lessons. There are obviously many other country and lower-level scenario studies, but most of these have focused on economic or social issues, with little or nothing to say about the environment.

Australia

- Australia: Resource Futures Program, CSIRO Sustainable Ecosystems: http://www.cse.csiro.au/futures/index.htm (Foran and Poldy, 2002).
- Future Makers, Future Takers: Life in Australia 2050 (Cocks, 1999).

India

- Green India 2047, TERI (Pachauri and Sridharan, 1998; Pachauri and Batra, 2001).

UK

- UK Foresight Environmental Future (UK DTI, 1999; UK DTI, 2002, see also the website at http://www.foresight.gov.uk/).

Russia

- Russia 2010 (Yergin and Gustafson, 1995).

China

- China's Futures (Ogilvy and Schwartz, 2000).
- The Forecast of China's Development Situation (Niu, 1997, cited in Raskin, 2000).

Estonia

- Estonia 2010 (Estonian Institute for Futures Studies, 1997).

Kenya

- Kenya at the Crossroads (Institute for Economic Affairs – Kenya and Society for International Development, 2000; Institute for Economic Affairs – Kenya and Society for International Development, 2001), see also the website at http://www.kenyascenarios.org/).

Mexico

- GEO Mexico (PNUMA et al., 2004).

South Africa

- South African Environments into the 21st Century (Huntley et al., 1989).

Tanzania

Tutafika: Imagining our Future – http://www.tutafika.org/.

Uganda

The Uganda Scenarios Project – http://www.scenarios.ws/uganda/.

Miscellaneous

- Scenarios for various African countries through the African Futures Program (Sall and Mureithi, 1999, see also the website at http://www.africanfutures.net/index.html).

- Scenarios from the IIASA Population, Development, and Environment project: Mauritius, Cape Verde, Yucatan Peninsula of Mexico, Namibia, Botswana, Mozambique (Lutz, 1994; Wils, 1996; Lutz et al., 2000; IIASA, 2001; see also the website at http://www.iiasa.ac.at/Research/POP/aboutpde.html?sb=14).

6. Closing Remarks

At the beginning of the chapter I posed the question as to how common environmental scenarios were. Based on the above review it is safe to answer that they are very abundant. Environmental scenarios are perhaps even more common than many practitioners realize. This provides a rich foundation upon which to draw lessons and build future scenario exercises.

In this survey, I have not tried to describe in any detail or pass judgment on any of the specific scenarios. Rather, I have chosen to simply illustrate the range of environmental scenarios that do exist. I have also discussed what is meant by the notion of environmental scenarios and presented various ways in which it may be useful to categorize and compare these and other scenarios. Still, the second question about the usefulness of environmental scenarios has been left unanswered. Other chapters in this volume address this question and also examine how they can be made more useful.

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