Background Paper

"Global Environmental Futures - Interrogating the Practice and Politics of Scenarios"

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by

Simone Pulver, Brown University (Simone_Pulver@brown.edu)[1]
Stacy VanDeveer, University of New Hampshire (Stacy.vandeveer@unh.edu)[1]

Background and Objectives

Scenarios have become a standard tool in the portfolio of techniques that scientists and policymakers use to envision and plan for the future. Defined as "plausible, challenging and relevant stories about how the future might unfold," scenarios integrate quantitative models with qualitative assessments of social and political trends (Raskin 2005). Arrayed on a spectrum of analytical tools, they fall between deterministic quantitative models of the future and purely narrative descriptions (Nakicenovic et al. 2000).

A brief survey across environmental issue areas reveals the ubiquity of scenario analyses in shaping the knowledge and expectations on which environmental governance is based. For example, scenario building and results representation were employed in the recent Millennium Ecosystem Assessment (MA) (Raskin 2005), and they have become accepted aspects of the work of the Intergovernmental Panel on Climate Change (IPCC) (Nakicenovic et al. 2000). In particular, the IPCC's "SRES" scenarios—alternative paths for global greenhouse gas emissions—are now widely used at various levels of public sector government and by many private and civil society actors to assess possible future implications and/or risks associated with climate change. Scenarios are also employed within the assessment bodies associated with the Convention on Long-Range Transboundary Air Pollution (CLRTAP),[2] by the teams developing UNEP's on-going Global Environmental Outlook (GEO) assessment (Potting and Bakkes 2004; UNEP 2002; UNEP 2006), by FAO's Integrated Assessment of Agricultural Science and Technology for Development program,[3] and by the international integrated water management community (Gallopin and Rijsbeman 1999). In the United States, various emissions scenarios were used within the Regional Greenhouse Gas Initiative (RGGI)[4] involving U.S. states in the Northeast and a host of public and civil society sector advocates for more significant U.S. climate policy action (UCS 2006).

Despite their prevalence, systematic analysis of scenarios is in its beginning stages. Fundamental questions remain about their methodological validity (i.e. Are scenarios "good science"?) and their policy utility (i.e. Do scenarios produce useful information?). There are,

[1] This paper presents ideas drawn from discussions among the four conference co-organizers: Yaakov Garb, Brian O'Neill, Simone Pulver, and Stacy VanDeveer. However, the paper was drafted by Pulver and VanDeveer, who take full responsibility for its contents.
[2] See http://www.unece.org/env/lrtap/
[3] See http://www.agassessment.org/
[4] See http://www.rggi.org

of course, multiple avenues by which to approach these fundamental questions. We focus on two. First, we examine scenarios as decision-support tools and call into question the automatic presumption that scenarios support or influence policy-making. Second, we step back from the functional purposes ascribed to scenarios and investigate them as social objects that link social worlds and influence political and social spheres. We conclude by summarizing the rationale and goals of the workshop.

Scenarios as decision-support tools

The origins of using scenarios as tools to support decision-making in complex situations trace back, most directly, to the security and futures scenarios of the 1940s and 1950s. They became popular as ways to assess emerging security threats during the Cold War and in the 1970s as ways to articulate the long-term implications of contemporary trends, including human population growth, oil consumption or deforestation (Berkhout and Hertin 2002; Raskin 2005). During that period, scenario analysis was further popularized by its use within the private sector (Garreau 1994; Schwartz 1991; Wack 1985a; Wack 1985b).

This general history glosses over different ways in which scenarios are used to support decision-making. Our analysis begins with a typology of three different logics by which scenario analysis brings information about the future—however contingent—to bear on decision-making in the present. We recognize that these categories are not entirely mutually exclusive, yet they are useful to rigorous thinking regarding the utility of scenarios.

1. Forecasting scenarios – Likely futures

The most common purpose ascribed to a scenario analysis is the goal of projecting into the future. These types of scenarios are often called forecasting scenarios. Outputs from forecasting scenarios are intended to be used both as inputs to other modeling exercises and as sources of information to improve policy-making.

Forecasting scenarios developed to address the limitations of future projections based solely on quantitative models. Standard integrated assessment models generate outputs by linking demographic, economic, and ecological dynamics via explicit assumptions about cause-effect connections, typically based on established trends and theoretically grounded relationships between variables. Such models are limited in their ability to incorporate complexity and indeterminacy (Berkhout and Hertin 2002). Moreover, they are limited to using knowledge that is sufficient to support meaningful quantification (Wehrmeyer, Clayton and Lum 2002). When used to project future trends, such models tend to draw on quantified relationships based on past trends as road maps for the future.

Such approaches have clear limitations. Scenario analyses attempt to overcome these limitations by generating a range of alternative futures based on various “story lines” (Raskin 2005). Story lines are narrative descriptions of the futures used to parameterize key relationships between variables. The advantages of the story line approach are two-fold. First, they are explicitly intended to accommodate surprises and discontinuities in the dynamics being modeled. Second, the narrative elements allow scenario developers to incorporate qualitative knowledge about potential futures into their analyses (De Jouvenel 2000).

The innovations embodied in forecasting scenario analysis have not gone unchallenged (Parson et al. 2006). The coupled quantitative-narrative outputs generated through scenario analysis raise questions about methodological validity and interpretation of results. In many ways, the narrative aspects of scenarios are incongruous with the methodology of quantification

underlying the modeled components of scenarios. Moreover, generating multiple projections of the future begs questions about which future is most likely.

Some of these concerns are beginning to be addressed. The next generation of global environmental scenarios will likely break from the past practice of generating alternative visions of the future based on a handful of story lines, with no assessment of which is the most likely. One group of scholars advocates assigning probabilities to alternative futures (Richels, Manne and Wigley 2004; Webster et al. 2003). A competing approach proposes increasing the number of scenarios to several hundred, creating a scenario probability space (Lempert, Popper and Bankes 2003).

Scenario users may be the ultimate arbiters in informing debates about techniques to refine the outputs of forecasting scenario analyses. For example, user needs are driving the trend to generate scenarios that are regionally specific (Grübler et al. in press). Likewise, the ideas of utility to policy-makers are mobilized in debates over assigning probabilities to alternative futures. Finally, there has been a clear progression in the extent to which scenario analyses have attempted to incorporate user input into the scenario development process. For example, the recent Millennium Ecosystem Assessment conducted focus group interviews in order to identify issues of concern to users. In addition, the MA has tracked the uptake of the MA scenarios by key stakeholders (Reid 2006). Prior scenario exercises did not engage in the same level of public outreach.

2. Robust decision-making – A full range of futures

In addition to projecting into the future, a second, closely-related purpose of scenarios is to allow policy-makers to evaluate the robustness of decisions across a range of potential futures. Unlike forecasting scenarios, in this application, the goal of scenario analyses is to capture the full range of alternative possible futures rather than to identify the most likely possible futures. Decision-makers seek to insure that present-day decisions will produce desired outcomes across a range of possible futures.

This type of scenario analysis is common practice in the private sector and in the national security domain, but less widely used in global environmental governance arenas. Royal Dutch/Shell's, a key pioneer in scenario analysis, established its internal scenarios group to support robust decision-making. Shell's scenarios efforts date back to the 1970s oil shocks, during which Shell managers were caught off guard by political developments that the company could have but did not anticipate and thus for which they did not prepare (Wack 1985a; Wack 1985b). Likewise, in the US, national security agencies, such as the Central Intelligence Agency, Department of Defense, and the National Intelligence Council regularly develop scenarios focused on threats to U.S. security or U.S. interests around the world (NIC, 2004).

3. Back-casting scenarios – An ideal future

A third type of scenario defines a desirable future and examines various pathways to reaching that future (Berkhout and Hertin 2002; Raskin 2005). These types of back-casting scenarios are built around creating consensus around a particular future to strive for or a particular future to avoid. The scenario then lays out the range of trajectories by which to reach or avoid particular future outcomes. It is important to maintain the distinction between backcasting and forecasting scenarios. While forecasting scenarios may include one or two projections into future that developers/participants most want to see, these are not back-

casting scenarios in that they do not pre-identify the future outcome and they do not explore the range of possible trajectories to reach that outcome.

We consider this typology a useful launch pad for an analysis of scenarios as decision-support tools for two reasons. First, it is helpful in clarifying the different types of knowledge about potential futures that constitute the field of scenario analysis. Second, it provides one useful framework for developing research questions. For example, the typology suggests questions regarding current best practices in each of these forms of scenario analysis. One might also ask about differences in scenario development techniques and user evaluations of policy utility across scenario type. Are the applications of scenario analyses consistent with their underlying design principles? Do scenario goals match up with scenario audiences across different scenario types?

Scenarios as social processes

Taking a step back from the immediate, functional goals of scenario analyses reveals a second layer to the roles of scenarios in global environmental governance. Scenario exercises are social processes. For example, they can serve to build networks of individuals linked by common concerns, generate shared understanding, or stabilize interaction between different social worlds. Social science approaches from the disciplines of science and technology studies, sociology, and political science all provide insight in the "social work" done by scenarios.

Scholarship in the field of Science and Technology Studies (STS) offers a number of ways to understand scenario building and reporting processes as knowledge production processes and the implications of viewing scenarios as "artifacts." First, one might seek to explore the "boundary work" involved with scenario development and use or to see scenarios as "boundary spanning" artifacts (Gieryn 1999; Guston 1999; Jasanoff 1990). These concepts help us to explore how tensions and debates endemic <u>within and between</u> scientific research agendas and policymaking agendas are contested and, perhaps, settled (or temporarily stabilized) through the use of scenarios. Scenarios can be understood as "boundary objects" that link different social worlds, such as science and non-science (Star and Griesemer 1989). Individuals and organizations within each social sphere use them for specific purposes, while maintaining the objects' identity and creating a sphere in which they can collaborate and co-exist. Thus, perhaps scenarios provide a sheltered context for the usual confusion, contestation, or conflict that accompanies boundary work. This function, like Shackley and Wynne's (1996) "boundary ordering devices," produces consistency, despite the fact that boundaries between science and policy are inconsistent and dynamic. One might ask how scenarios interact with and organize the various levels of scientific understanding and modeling underlying them.

Following Latour (1987) and Jasanoff (2004), scenarios might also be understood as spheres of "co-production," where knowledge and social order are produced simultaneously. Scenarios, in this framework, co-produce knowledge and social order by facilitating collaboration between scientific and technical experts of various types and policymakers and other non-scientists. An advantage of the co-productionist approach is that it calls attention to audiences for information and knowledge. One can explore how both knowledge creators (those participating in a scenario process, for example) and their audiences are (or can be) trained to understand information (images, texts, etc.) in particular ways that link their social reality or world views with particular knowledge sets (VanDeveer 2004). How do scenarios frame debate and collective understanding, through discourse, participation patterns, and the use of images?

For example, images of air pollution transport and deposition patterns across the European continent help to convey the notion that European nations share an airshed and that no national government could protect national air quality on its own (VanDeveer, 2004). In the climate change arena, the now ubiquitous graph of carbon dioxide concentration measurements at the Mona Loa Observatory—the so called "hockey stick"—has become an iconic image associated with global warming (Szasz 1994).

Analyses of scenarios based in sociology and political science would emphasize different aspects of the "social work" done by scenarios. A sociological analysis of scenarios might focus on the organizations within which scenarios are produced (McNamara 2001). Under what conditions do modern bureaucratic organizations, both public and private, enable the deliberative processes that drive effective scenario analyses? How do various institutional contexts within which scenario analysis is employed matter for the production, dissemination, and use of the scenarios themselves or their results? A second set of questions of interest to sociologists focuses on the various networks created through scenario development processes. Network characteristics such as network density and network structure may explain the extent to which certain scenario analyses are evaluated as more or less useful by decision-makers (Canan and Reichman 2002). For example, scenario users can be categorized according to their proximity to the scenario production process. Scenario users include those that both generate scenario outputs and use those outputs in subsequent analyses, i.e. producer-users. Other users can be characterized as recipient-users, operating in national and sub-national policy arenas (UCS 2006). Different users with differing interests and perspectives are likely to attribute varying levels of technical credibility, relevance (to them) and legitimacy to particular scenario development processes and outputs (Mitchell et al. 2006). Finally, an examination of the ways in which scenarios can be used to highlight questions of equitable development or to frame and mobilize social action are potential contributions of sociological approaches. How do they circulate and mobilize change in the world? That is, what is the relationship of scenario development processes and outputs to human decisions and human action? How do scenarios engage, reproduce, and challenge global patterns of inequality, representation, and resource consumption?

Likewise, political science approaches would emphasize the extent and nature of the influence of scenario development processes and products on political discourse and/or the actions or knowledge of political actors. For example, work on the influence of scientific and technical assessment on politics focused inquiry on the changes (if any) induced in particular "issue domains" (Farrell and Jaeger 2005; Mitchell, et. al. 2006). Such work suggests that scenarios' influences might be traced to changes scenarios induced in actors' knowledge or understandings of particular issues, because of processes of social learning and/or because particular "problems" or "solutions" were framed or reframed by scenario development. Both sociological and political science approaches engage analytical tools such as qualitative comparative analysis, process tracing, discourse analysis and/or network analysis to identify and unpack the social processes that connect scenario development to political action or particular policy outcomes or debates.

Interrogating Scenarios: The Brown University Scenarios Workshop

The consideration of scenarios both as decision-making tools and as social processes highlights the myriad of questions to be asked about the practice and politics of scenarios. One primary goal of the scenarios workshop is to refine the list of promising research

directions. We hope, through the workshop, to lay the groundwork for a multi-year research effort designed to advance debate and methods for improving scenario analysis. The workshop is structured to achieve this goal in three ways.

First, the presentations focused on the MA, IPCC SRES and other current scenario analyses will provide an overview of current practices/best practices in scenario production and scenario use across a range of scenario types. Panelists with address impacts scenarios, emissions stabilization scenarios, ecosystem scenarios, and private sector and civil society environmental scenario analyses.

A second group of presenters contributes to current knowledge of environmental scenarios the greater experience generated from over four decades of scenario development in other issue domains. Scenario exercises have long been employed around issues such as national and international security, human population trends, public health, and energy supply and demand (UN 2005; van Vuuren, Weyant and Chesnaye 2006; Wei et al. 2005). By including these other domains we can access a larger body of empirical research. For example, a substantial literature has assessed the accuracy of past projections of both population (Bongaarts and Bulatao 2000) and energy prices and demand (Craig, Gadgil and Koomey 2002; O'Neill and Desai 2005). Beyond assessing numerical accuracy, analyses have investigated why population and energy scenarios have gone wrong, and what influence they have had (or not) on policy processes (Greenberger 1983). Experience in the security domain can offer insight into effective linkages with policy communities. More than any other issue domain, scenario analysis around security issues has been most directly and effectively linked to a policy agenda. Furthermore, population, energy, and security issues no longer constitute separate domains. Environment-related scenario analysis increasingly intersects with other substantive areas of scenario analysis. For example, the analysts at the U.S. National Intelligence Council plan to incorporate climate change and related aspects of land use change into their next global trends scenario, due out in December of 2008 (NIC 2004). These reports highlight geopolitical, demographic, economic and environmental trends of interest to US security policy and foreign policy makers.

The third element of the workshop structure is to bring into dialogue scenario practitioners, both producers and users, with social scientists. We expect this to be a productive exchange that will contribute social science insights to the analysis of scenarios while also establishing scenarios as scientific and social processes worthy of study within the social science community. Moreover, the workshop will expand the community of scholars, analysts and scenario practitioners engaged in concerted efforts to improve the practice of scenario development for environmental policy and to improve collective knowledge about the relationships of scenario processes and outputs to policy making.

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Catalogue of International Environmental Scenario Analyses

STUDY	Date	Horizons	Regions	Focus	Structure
Impacts of Climate Change: A System Vulnerability Approach to Consider the Potential Impacts to 2050 of a Mid-Upper Greenhouse Gas Emissions Scenario (Global Business Network)	2007	2050		Climate change	Starts by focusing on vulnerable systems, then considers what climate change might do to them
World Bank: The Road to 2050: Sustainable Development in the 21st Century	2006	2050	Global	Environment	Uses UN predictions of population and wealth as a basis for discussion of environmental impacts
Air Quality and Ancillary Benefits of Climate Change Policies (European Environment Agency)	2006	2030	Europe	Air quality	Analyzes projected changes in air quality and shows costs and benefits of climate and pollution policies
Millennium Ecosystem Assessment	2005	2050 & 2100		Ecosystems: changes in services and effects on humans	2 main dimensions: continuation of globalization versus fragmentation, reactive versus proactive responses to ecosystem deterioration 1. *Global Orchestration* (global, reactive): low population growth and high economic growth; investment in public goods, energy-intensive lifestyle 2. *Order from Strength* (regional, reactive): very high population growth and low economic growth; fragmented world preoccupied by security, not public goods 3. *Adapting Mosaic* (regional, proactive): high population growth, initially low economic growth that increases after 2020; diverse regional efforts to protect ecosystems 4. *TechnoGarden* (global, proactive): moderate population growth, relatively high and increasing economic growth; globally connected world with strong environmental policy and technology
UN National Intelligence Council's 2020 Project: "Mapping the Global Future"	2004	2020	Global	Focuses on economics and security, includes environmental issues under the heading of "ethical issues"	*1. Davos World* robust economic growth, led by China and India, over the next 15 years reshapes the globalization process, giving it a more non-Western face and transforming the political playing field as well. 2. *Pax Americana* US predominance survives radical changes to the global political landscape and serves to fashion a new and inclusive global order.

					3. A New Caliphate a global movement fueled by radical religious identity politics could constitute a challenge to Western norms and values as the foundation of the global system *4. Cycle of Fear* concerns about proliferation might increase to the point that large-scale intrusive security measures are taken to prevent outbreaks of deadly attacks, possibly introducing an Orwellian world
The Future for Fisheries (Pauly et al., *Science*)	2003			Fisheries	Applies the 4 UNEP scenarios (*Markets First; Policy First; Security First; Sustainability First*) to an analysis of marine fisheries
UNEP's 3rd Global Environmental Outlook (GEO-3)	2002	2032	6	Environment	*Markets First; Policy First; Security First; Sustainability First* (correspond respectively to 1a, 1b, 2b, and 3b above)
African Environment Outlook (UNEP)	2002	2032	6	Environment	(uses the 4 categories from GEO-3, originally from GSG) 1. *Market Forces* 2. *Policy Reform* 3. *Fortress World* 4. *Great Transitions* Applies scenarios to African context via demographics (total population and the urban population figures for Africa, and for each of its sub-regions); economy and society (GDP as Purchasing Power Parity); agriculture and forestry (severely degraded cropland); and environment (water use and urban household water pollution) *Driving forces*: demographics, economics, social issues, culture, technology, environment, governance
Global Water Outlook to 2025: Averting an Impending Crisis (International Food Policy Research Institute)	2002	2025	36	Water access, consumption	Predicts water access and consumption in each country/group of countries in 2025
OECD's *Environmental Outlook*	2001	2020	10	Environment in OECD countries	*Reference* with policy variants (e.g. subsidy removal, eco-taxes)
Asian Environment Outlook (Asian Development Bank)	2001		Asia	Environment	Policy recommendations based on projected future trends due to “driving forces of change”: population explosion; urbanization and industrialization; income growth and inequality; technological change; governance; institutions, policy, and the market

IPCC's Special Report on Emissions Scenarios	2000	2100	4	Climate Change	AI: rapid market-driven growth with convergence in incomes and culture A2: self-reliance and preservation of local identities, fragmented development B1: similar to AI, but emphasizes global solutions to sustainability B2: local solutions to economic, social, and environmental sustainability
World Water Vision	2000	2025	18	Freshwater Crisis	*Business-as-usual*: current water policies continue, high inequity *Technology, Economics, and the Private Sector*: market-based mechanisms, better technology *Values and Lifestyles*: less water-intensive activities, ecological preservation
EPA's Environmental Scenarios Project	2000			Aquifer depletion/ water quantity; sprawl; biotechnology and nanotechnology; chemicals in the environment; climate change	2 main dimensions: economic growth and social cohesion (defined by shared environmental values versus environmental indifference, economic inequities, social justice) 1. *Eco-efficiency revolution* (high growth and cohesion) 2. *Full Speed Ahead* (high growth, low cohesion) 3. *Soft Landing* (low growth, high cohesion) 4. *A Darker Age* (low growth and cohesion)
UNEP's 2nd Global Environmental Outlook (GEO-2000)	2000		6	Environment	Region-specific studies undertaken to analyze policy alternatives (example: Asia and Pacific alternative policy study on emission reductions for sulphur and nitrogen oxides under different scenarios: business as usual, single policy packages such as the introduction of clean technologies, efficient transportation and fuel switching, and a combination of all three called the multiple policy package)
Global Biodiversity Scenarios for the Year 2100 (Sala et al., *Science*)	2000	2100	Divided by biome	Biodiversity	Developed global scenarios in 10 terrestrial biomes and in freshwater ecosystems based on analysis of 5 drivers: changes in land use, atmospheric CO2 concentration, nitrogen deposition and acid rain, climate, and biotic exchange For each biome, 3 alternative scenarios
World Business Council for Sustainable Development	1997	2050	n.a.	Business and sustainability	*FROG1:* market-driven growth, economic globalization *GEOpolity*: top-down approach to sustainability *Jazz*: bottom-up approach to sustainability, ad hoc alliances, innovation

UNEP's 1st Global Environmental Outlook (GEO-1)	1997		6	Environment	Compares projected future under business as usual with a brief discussion of "alternative development scenarios" illustrating that technology transfer can lead to significant changes in energy consumption, land use, and carbon dioxide emissions
Global Scenario Group (GSG)	Started in 1995	2050	11	Environment; poverty reduction; human values	1. *Conventional Worlds*: gradual convergence in incomes and culture toward dominant market model a) Market Force: market-driven globalization, trade liberalization, institutional modernization b) Policy Reform: strong policy focus on meeting social and environmental sustainability goals 2. *Barbarization*: social and environmental problems overwhelm market and policy response a) Breakdown: unbridled conflict, institutional disintegration, and economic collapse b) Fortress World: authoritarian rule with elites in "fortresses," poverty and repression outside 3. *Great Transitions*: fundamental changes in values, lifestyles, and institutions a) Eco-Communalism: local focus and a bio-regional perspective b) New Sustainability Paradigm: new form of globalization that changes the character of industrial society

(Source: Drawn primarily from Nakicenovic et al. 2000, Parson et al. 2007, Raskin 2005; for other sources please see text)

Pre-1995 Global Scenarios

STUDY	Date	Horizons	Regions	Focus	Structure
The Coming Anarchy, Kaplan	1994				Narrative-based; dark vision of increases in demographic, environmental and social stresses; surging populations, disease, and depletion of natural resources will lead to mass migration and group conflict
Scanning the Future, The Dutch Central Planning Bureau	1992	2015			Modeling-based; macroeconomic model 1. *global crisis*, overall economic decline 2. *balanced growth* 3. *European renaissance* 4. *global shift* 3 and 4 predict economic stagnation in some regions and expansion in others, but all scenarios optimistically predict convergence between rich and poor regions
Into the 21st Century, Burrows et al.	1991				Narrative-based; 1. *pessimistic*, if present trends continue 2. *piecemeal*, fragmented attempt to find environmental and social solutions 3. *optimistic*, dramatic changes in attitudes and values toward altruism, cooperation,a dn ecology
Surprising Futures, Svedin and Aniansson	1987	2075			Narrative-based; results of workshop of social and natural scientists 1. *the big load*, continues dominant trends 2. *the big shift*, toward new centers of power in India & China 3. *history lost*, future of crises 4. *hope regained*, environmentally, socially balanced global development
The Sane Alternative, Robertson	1983				Narrative-based 1. *business as usual* 2. *disaster* 3. *authoritarian control* 4. *hyper-expansionist* 5. *sane, humane, and ecological* Emphasizes need for significant psychological and social changes
The Global 2000, Barney	1980	2100		11 sectors: pop, tech, economy, climate, food, fisheries, water, forestry, energy	Modeling-based; uses set of linked models to predict continuation of trends in population, natural resources, and environment; predicts huge population growth leading to global poverty

The Next 200 Years, Kahn et al.	1976				Narrative-based
The Future of the World Economy, Leontief	1976	2000	15	Prospective UN economic policies	Modeling-based; tracked economic flows An optimistic scenario: income gap between industrial and developing countries decreases by one half by 2000 Sustained economic growth will require large capital investments in developing regions and significant political, social and institutional changes
Catastrophe or New Society? A Latin American Model, Herrera et al.	1976	2060	4	Agriculture, nutrition, housing, capital goods, other	Modeling-based; *Bariloche Model* used to address sociopolitical issues; backwards-oriented
Mankind at the Turning Point, Mesarovic and Pestel	1974		10 (follow-up project to *Limits to Growth* aimed at regional disaggregation)	Economy, population, food, energy, environment	Modeling-based; used 5 different sub-models for each of the categories listed impending crisis, need for significant changes
The Limits to Growth, Meadows et al.	1972	2100	Global model	Population, capital, agriculture, nonrenewable resources, pollution	Modeling-based; "systems dynamics model" *14 scenarios* with different assumptions on technical progress, social policy, and value changes

(Source: Raskin 2005)