Methods for Building Scenarios of the Environment

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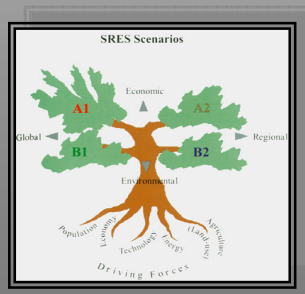

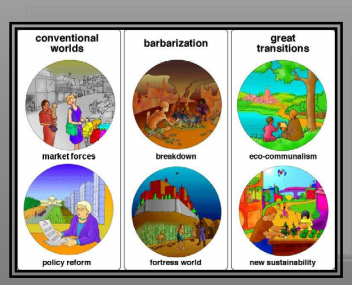

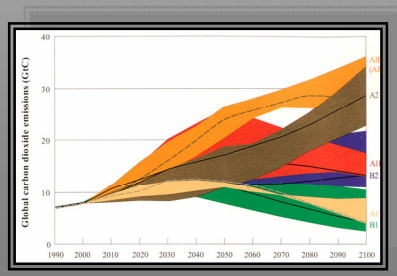

Outline of Lecture

1. Introduction & Background
2. Types of Scenarios
3. Scenario Development

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Definitions

What are Scenarios?

A plausible description of how the future may unfold based on 'if-then' propositions. A typical scenario includes a representation of the initial situation and a sequence of events that describe the key driving forces and the changes that lead to an image of the future.

What they are *not:* Extrapolations, predictions

What is Scenario Analysis?

A procedure based on the development of scenarios, a comparison of scenario results, and an evaluation of their consequences. The goal of scenario analysis is to anticipate future developments of society and the environment, and to evaluate strategies for responding to these developments. A key idea is to explore alternative future developments.

Origin of current use of scenarios and scenario analysis

1. Scenarios as part of theater production.
2. Scenario analysis and the Cold War.
3. Herman Kahn bringing scenario analysis to the attention of the public and science community. (Kahn, H., Wiener, A.J. 1967. *The Year 2000.* MacMillan: New York.)
4. Use of scenario analysis by the big corporations.
5. The current use of scenario analysis for environmental studies.

Elements of a Scenario

1. **A base year (or period)** and a description of the state of things in this year.
2. **A time horizon (or period) and time steps** – the end point in time of the scenario -- and a description of the state of things at that time.
3. **A geographic coverage** – the spatial coverage of the scenarios – city, country, global?
4. **A description of step-wise changes** – A description of the events between the base year and time horizon which explains how the future situation occurred from the present.
5. **Driving forces or uncertainties** – The main factors that influence the step-wise changes of the scenario.
6. **Storyline** – A narrative that presents the important aspects of a scenario, including the relationship between driving forces and events of the scenario.

What are the two main objectives of scenario analysis of the environment?

1. **To imagine the future environment and society**:
   To imagine/estimate future states of the environment and society.
2. **To test strategies**: “Wind tunnel”. To test strategies of environmental protection / sustainable development against the backdrop of future developments of the environment and society. To identify robust strategies.

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Example: The two main objectives of Scenario Analysis

1. Imagine Future Environment & Society

You are one of the world's major developers of electronic parts for wind generators and you want to develop a strategy for introducing your product into the German market where wind electricity has one of the highest market shares in the world.

- In 2015 there is a major change in the government of Germany, and the new government eliminates subsidies for wind and other alternative energies.
- An accident at a nuclear power plant in 2017, and a large coal mining accident in 2019 lead to an acceleration of the phasing out of coal and nuclear electricity in Germany.

2. Test Strategies: Under the above scenario, what should be your business strategy for the next 5, 10, 15 years?

What are other objectives?

To raise the awareness of managers and decision makers about the uncertainty of the future. To alert them to emerging problems and possible surprises important to decision making and policy.

To help managers and decision makers to “think big” about a problem – creative, comprehensive, open.

♦

Cc imp ad
Ma ec ecosy

When to use scenario analysis?

Best for long-term uncertain situations, with scarcity of data and large number of non-quantifiable factors.

What are the alternatives to scenario analysis?

- Technical reports that evaluate different future alternative policies.
- Computer simulations that extrapolate current trends.
- Reports from expert panels.
- Public hearings and/or expert hearings.
- Participative methods such as the Delphi studies, focus group studies that may include decision-makers, stakeholder and/or experts.

  Note -- Scenario analysis would complement some of these approaches and replace others.

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Part 2. Types of Scenarios

Deductive ←→ Inductive

Exploratory ←→ Anticipatory

Qualitative ←→ Quantitative

Deductive ←→ Inductive

Deductive Scenarios

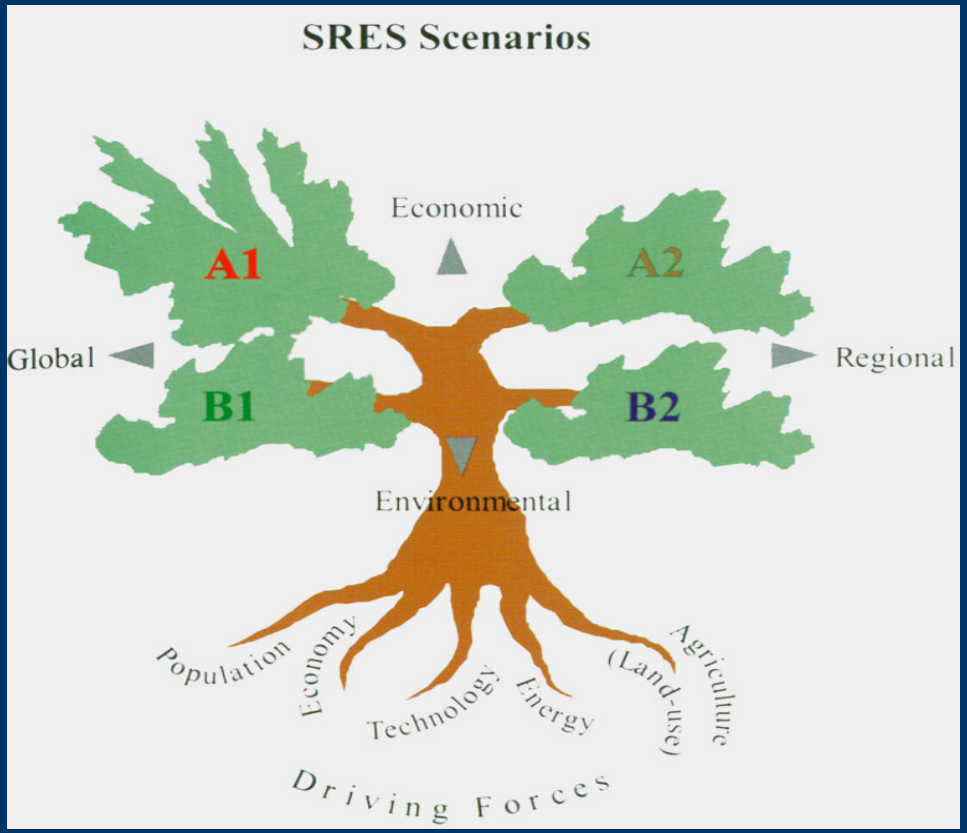
Scenarios derived from a framework which organizes the big uncertainties or questions about the future into a logical form. First framework established, then scenarios *deduced* from the framework.

Inductive Scenarios

Scenarios derived from taking into consideration all data and ideas about the future. Scenarios built step-wise, “bottom-up”. First all data are considered, then insights about the future are *induced* from this study of the data.

Example: Deductive Scenarios

Scenarios of Greenhouse Gas Emissions (SRES)
from the Intergovernmental Panel on Climate Change



Framework for scenarios:

- **Globalization or regionalization**
- **Accent on economic values or environmental values**

Example: Inductive Scenarios

World Water Vision Scenarios
-Developments up to 2025 -

Business as Usual [BAU]

•Continuation of current trends

Technology, Economics, and Private Sector [TEC]

•Investments in Technology -> Big gains in efficiency of water use
•Large expansion of irrigated area (+ 23 %)

Values and Lifestyles [VAL]

•Behavioral changes -> Significant structural change in water sector
•Small increase in irrigated area (+ 5 %)

Exploratory ←→ Anticipatory

Exploratory Scenarios ("descriptive")

Present → Future

Departure point: The current situation and then describe the steps that lead to a future situation.

Anticipatory Scenarios ("prescriptive", "normative")

Present ← Future

Start with a prescribed vision of the future (either optimistic, pessimistic, or neutral) and then work backwards in time to visualize how this future could emerge.

Example: Exploratory vs. Anticipatory Scenarios

Exploratory Scenario of German Wind Energy Market

Now: Wind energy is subsidized in Germany but public opposition to its landscape impacts is growing.

2013- 15: Government changes in Germany. Subsidies to wind energy and other renewable energies drastically reduced. For energy security reasons, legislation is passed to support the continued usage of coal-fired and nuclear-fired power plants.

2018: Market for wind generators crashes in Germany.

Anticipatory Scenario of German Wind Energy Market

2020: The demand for wind generators has doubled between 2005 and 2015.

2015: The European Commission begins large subsidies for wind energy.

2010: Accidents in coal-fired and nuclear power plants make this form of electricity very unpopular.

Qualitative ←→ Quantitative

Qualitative Scenarios

In form of:

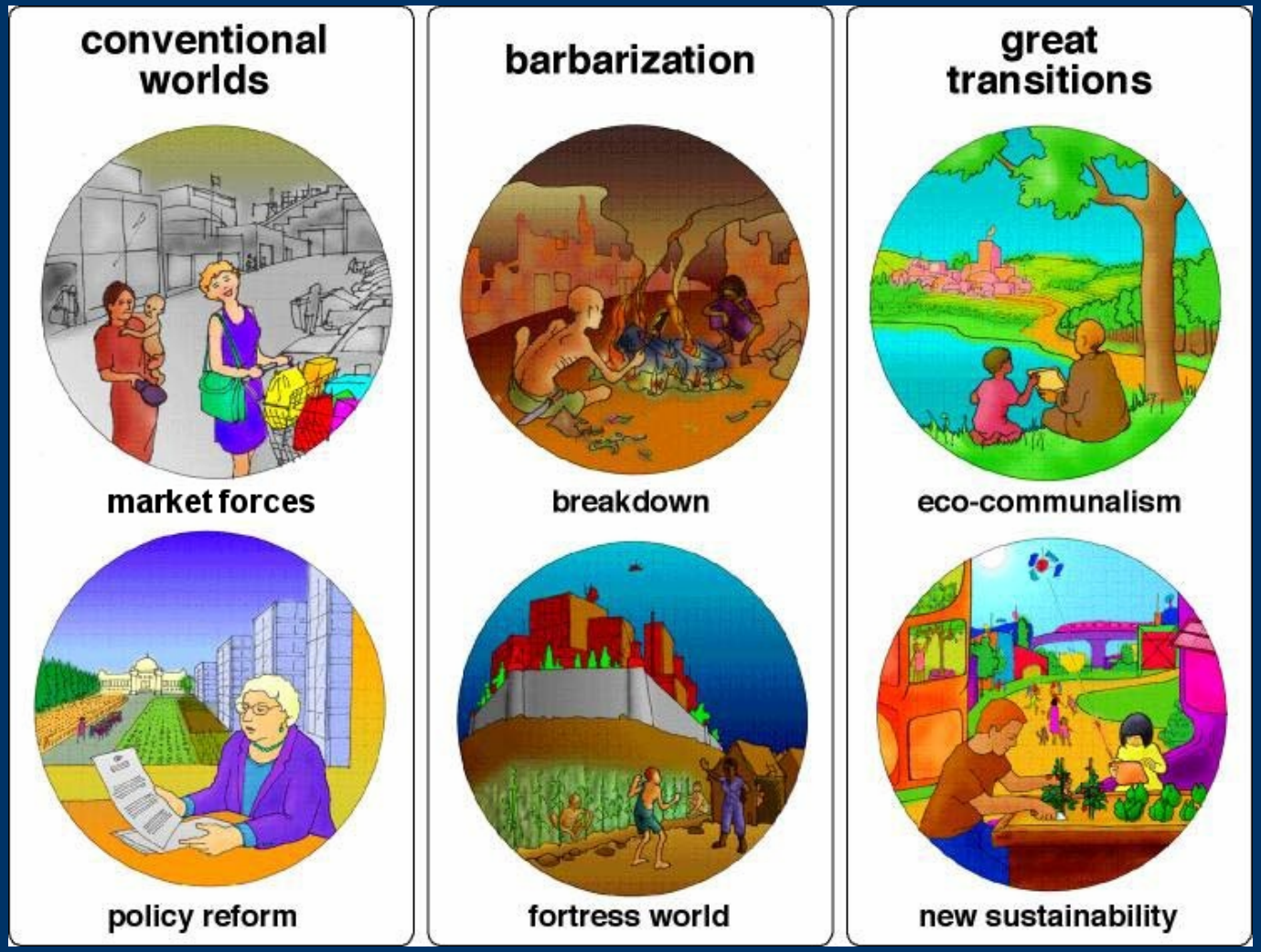
- **visual symbols**: diagrams; pictures
- **words**: written phrases, outlines; or storylines

Most common form:

Storylines – Narrative description of scenario, highlighting main features, and relationship between driving forces and main features.

Qualitative Scenarios: Visual Symbols

(Source: Global Scenarios Group, SEI & others)



Qualitative Scenarios: Storyline

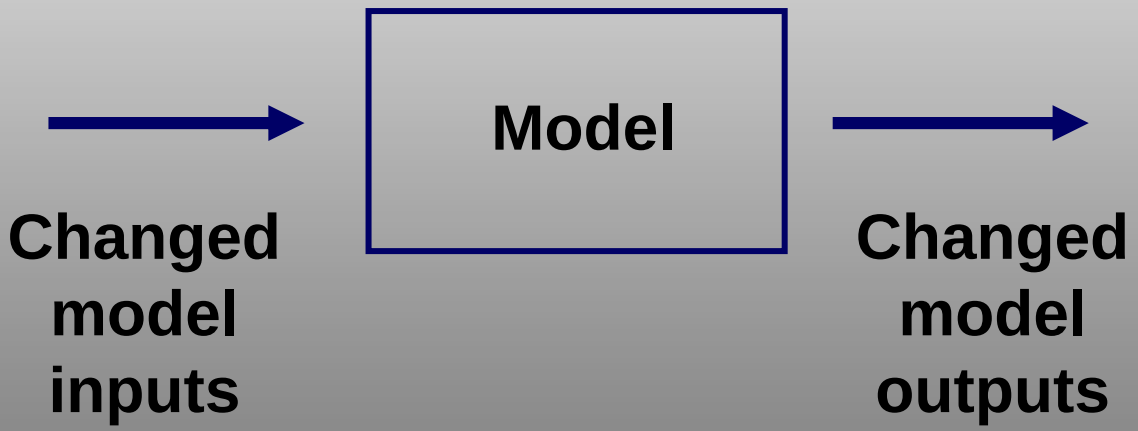
(Excerpt of the A1 storyline from the IPCC-SRES scenarios.)

“ In the A1 scenario family, demographic and economic trends are closely related, as affluence is correlated with long life and small families (low mortality and low fertility). Global population grows to some nine billion by 2050 and declines to about seven billion by 2100…

The global economy expands at an average annual rate of about 3% to 2100 … While the high average level of income per capita contributes to a great improvement in the overall health and social conditions of the majority of people, this world is not necessarily devoid of problems. In particular, many communities could face some of the problems of social exclusion encountered in the wealthiest countries during the 20th century … “

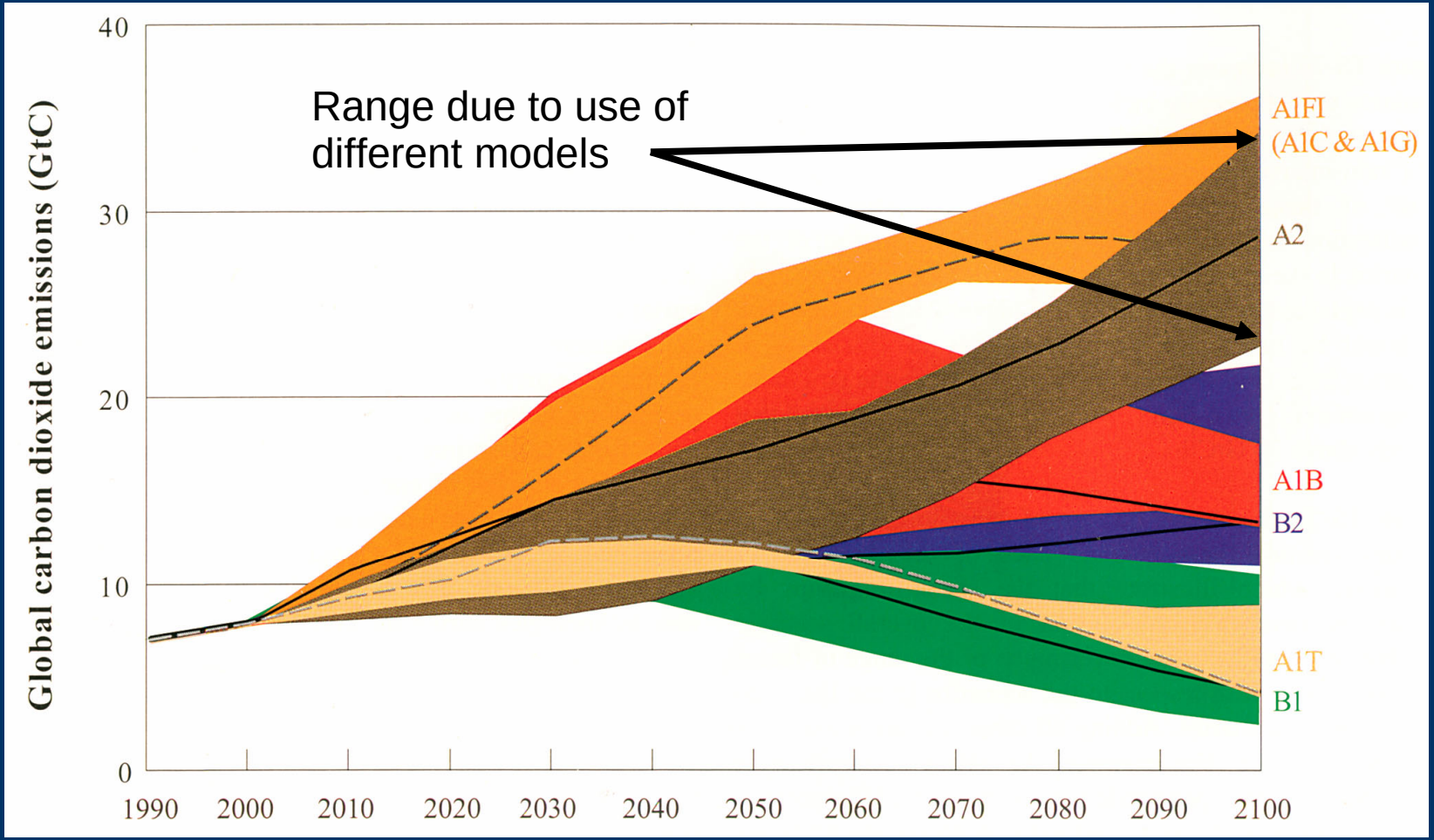
Quantitative Scenarios

- Numerical information
- Commonly computed with models



Quantitative Scenarios

(IPCC-SRES Greenhouse Gas Emission Scenarios 2000-2100)



Advantages/Disadvantages

Qualitative Scenarios

Advantages: Understandable, interesting; represent views and complexity of many different interests.

Disadvantages: Arbitrary, tough to identify or test underlying assumptions; do not provide numerical information.

Quantitative Scenarios

Advantages: “Scientific” (based on models); Numerical information; can identify underlying assumptions.

Disadvantages: Models have limited view of the world and are often not transparent; exactness gives illusion of certainty.

Story and Simulation Approach (SAS)

A type of scenario analysis …

… produces both **qualitative** information (storylines) and **quantitative** information (model calculations) and combines their advantages:

Qualitative -- understandable, express complex dimensions of problem.

Quantitative -- consistency check of different assumptions of qualitative scenarios, provide quantitative data

… is an **iterative process** engaging both stakeholders and environmental modelers

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Where has the SAS Approach been used?

In many different international scenario exercises, e.g.

- Intergovernmental Panel on Climate Change
- Millennium Ecosystem Assessment
- UNEP Global Environmental Outlook
- World Water Commission

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SAS Approach - Who is involved?

(Example - GLOWA Scenarios Exercise on the Jordan River Valley)

Scenario Panel: Stakeholders. Representatives from water & agriculture ministries of Israel, Jordan, and Palestinian Authority; NGOs; scientific advisors. → *Develop qualitative scenarios ("storylines").*

***Scenario Team*:** Glowa-Jordan scientists (Univ. Kassel & Tübingen
→ *Coordinate scenario exercise.*

***Project Scientists*:** Partners from scientific sub-projects of the Glowa-Jordan project. Support storyline development with modeling analyses.
→*"Quantify" scenarios (with modeling and other analysis)*

Moderator Team → *Facilitate Scenario Panel meetings.*

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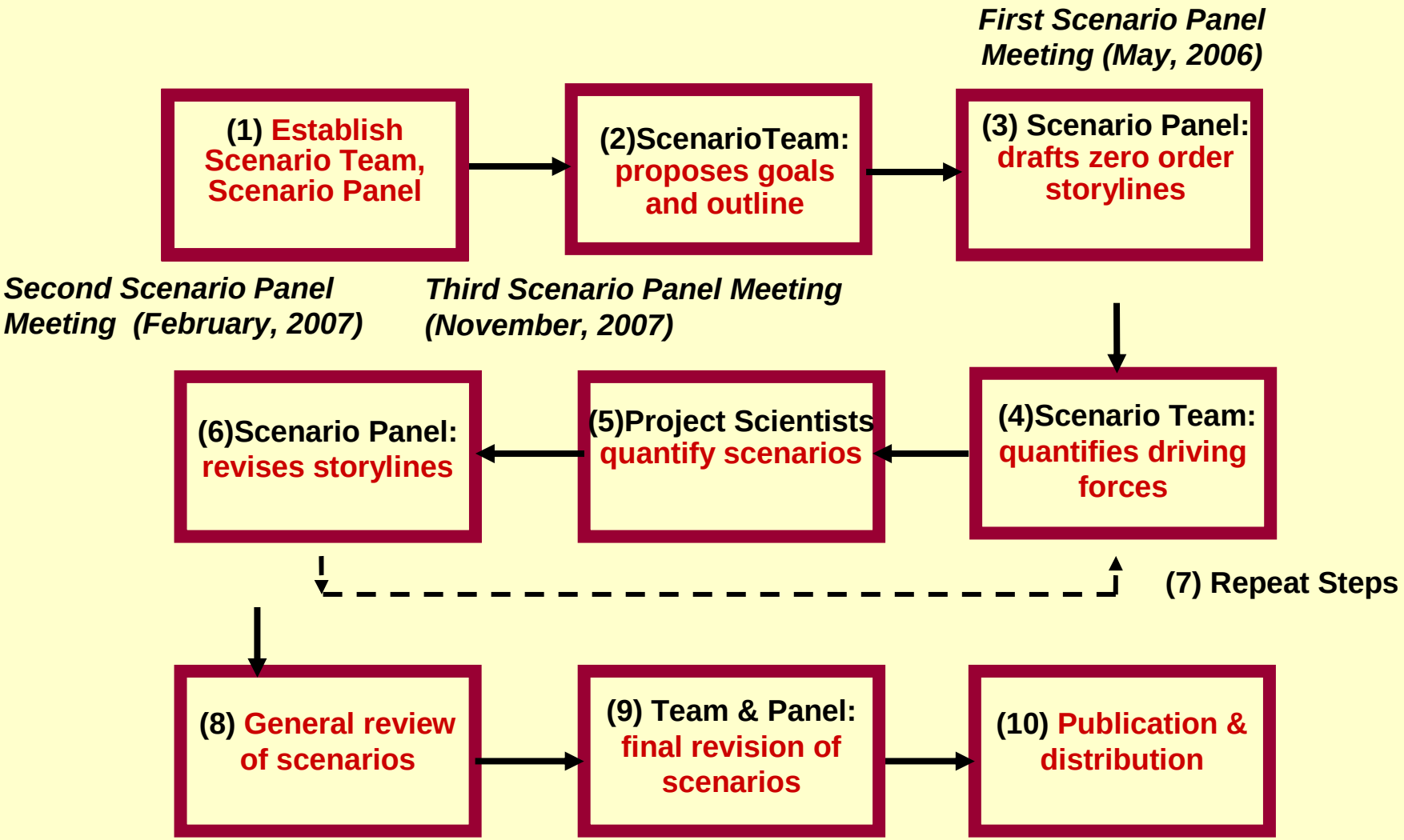
SAS Procedure

(Example - GLOWA Scenarios Exercise on the Jordan River Valley)



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Steps in Scenario Development

1. Select objectives and boundary conditions
2. Select themes
3. Select actors & factors
4. Develop mini-scenarios for each theme
5. Reduce number of mini-scenarios
6. Write full scenarios – storylines

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Step 1. Objectives and Boundary Conditions

Objective – What should the scenario analysis accomplish? Examine future state of the environment? Test future strategies? Inform managers about emerging problems? Other?

Boundary Conditions:

- Base year
- Time horizon
- Time steps
- Geographic coverage

Step 1. Example: Objectives and Structure

Objectives:

You are one of the world's major developers of electronic parts for wind generators and you want to develop a strategy for introducing your product into the German market where wind electricity has one of the highest market shares in the world.

The objective of the scenario analysis is to develop scenarios that describe the possible business environment in Germany for expanding wind energy production.

Boundary Conditions:

- Base year: 2005
- Time horizon: 2020
- Time steps: 2010, 2015
- Geographic coverage: Germany

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2. **Select themes**
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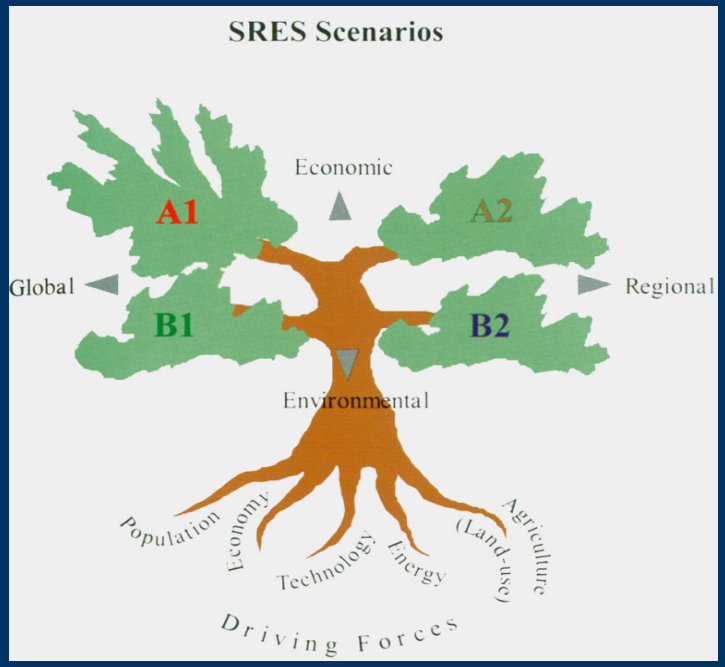
Step 2. Select Themes of Scenarios

Each scenario should have a main theme or message.
e.g. 4 themes could give 4 scenarios

Themes based on main uncertainties or questions about the future.

Step 2. Example: Main Themes of Greenhouse Gas Emission Scenarios of the Intergovernmental Panel on Climate Change



<u>2 main uncertainties/questions regarding trend of greenhouse gas emissions:</u>

1. Will the world‘ economy **globalize** or **regionalize** (e.g. Will there be fewer or more trade barriers?)
2. Will society lean towards **economic** or **environmental** values?

Step 2. Example: Selecting main themes of a scenario

What are major uncertainties or questions about the future business environment for wind energy in Germany?

1. Coal and nuclear?

Will coal-fired and/or nuclear electricity be phased out?

2. EC subsidies?

Will the European Commission subsidize wind energy?

Example: Selecting main themes of a scenario

Coal and/or nuclear?

	Coal and nuclear phased-out	Coal and nuclear increase
EC subsidies for wind	Theme 1. An optimistic scenario: *Fair breeze*	Theme 2. A mixed scenario: *Wind competes*
No EC subsidies for wind	Theme 3. A mixed scenario: *Wind fills the gaps*	Theme 4. A pessimistic scenario: *Wind becalmed*

EC subsidies?

Major uncertainties

Major uncertainties

Steps in Scenario Development

1. Select objectives and boundary conditions
2. Select themes
3. **Select actors & factors**
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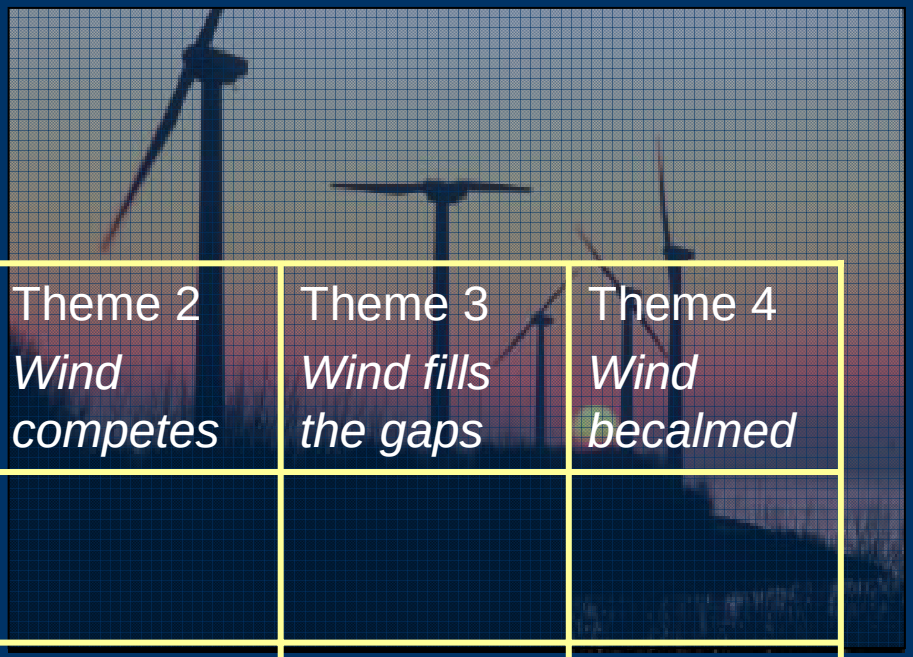
Step 3. Select Actors and Factors

Select a short list of:
... **Main actors** – institutions that will play an important role in the scenario – e.g. financial institutions, governments, special interest groups,...
... **Main factors** – main variables that will play an important role in the scenario – e.g. rate of increase of market share, number of employees in the firm, rate of subsidies ....

Step 3. Example: Selecting Actors and Factors



Actors & Factors	Theme 1 *Fair Breeze*	Theme 2 *Wind competes*	Theme 3 *Wind fills the gaps*	Theme 4 *Wind becalmed*
Factor: Rate of increase of demand for wind-electricity	High	Medium	Low to Medium	Low
Actor: Acceptance of ministeries of foreign wind companies	High	Medium	Medium	Low
Actor: Position of environmentalist groups on wind energy	Against	For	For	For

Steps in Scenario Development

1. Select objectives and boundary conditions
2. Select themes
3. Select actors & factors
4. **Develop mini-scenarios for each theme**
5. Reduce number of mini-scenarios
6. Write full scenarios – storylines

Step 4. Develop Mini-Scenarios

- For each theme, construct an outline of a scenario – a “mini-scenario”. Phrase or tabular form.
- Consists of a description of step-wise changes – A description of the events between the base year and time horizon which explains how the future situation evolved from the present. Describes, among other things, the driving forces or uncertainties of the scenario.
- Other points:
  - Maintain internal consistency
  - Include main actors and factors

Step 4. Example: Develop mini-scenarios

Mini-Scenario for “Fair Breeze” (Theme 1)

2010: Government changes in Germany & eliminates subsidies. But soon after, EC begins even stronger subsidies for wind and other renewable energies.

2015: In last five years many German firms have been organized to help foreign firms exploit EC subsidies in Germany. During same period -- 2 major coal mining accidents have occurred in East Germany. German government announces plan to phase out subsidies for brown coal production within 10 years.

2020: New agency set up in Germany to administer hugely increasing demand for wind electricity. Strong opposition from environmentalist groups because of big impact of wind generators on natural landscape.

Steps in Scenario Development

1. Select objectives and boundary conditions
2. Select themes
3. Select actors & factors
4. Develop mini-scenarios for each theme
5. **Reduce number of mini-scenarios**
6. Write full scenarios – storylines

Step 5. Reduce Number of Mini-Scenarios

Reduce total number of mini-scenarios to a manageable number.

Eliminate implausible mini-scenarios.

Combine similar mini-scenarios.

2 main uncertainties, each with 2 possible values, yield 4 themes/scenarios:

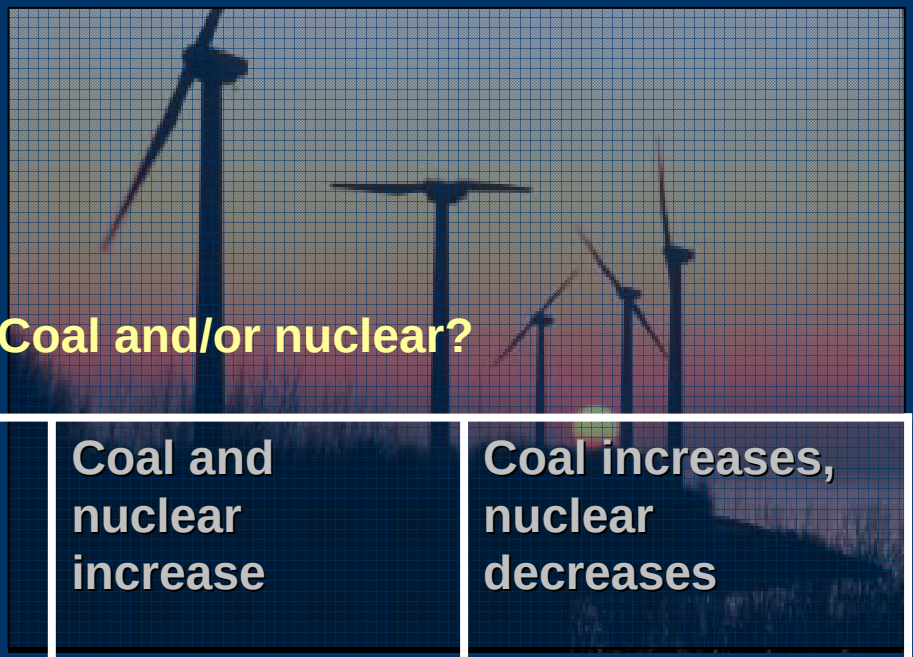
Coal and/or nuclear ?

EC subsidies ?	Coal and nuclear phased-out	Coal and nuclear increase
EC subsidies for wind	Theme 1. An optimistic scenario: *Fair breeze*	Theme 2. A mixed scenario: *Wind competes*
No EC subsidies for wind	Theme 3. A mixed scenario: *Wind fills the gaps*	Theme 4. A pessimistic scenario: *Wind becalmed*

Major uncertainties

Major uncertainties

Too many scenarios: e.g. 2 main uncertainties, each with 3 possible values, yield 9 themes/scenarios:



EC subsidies?

	Coal and nuclear phased-out	Coal and nuclear increase	Coal increases, nuclear decreases
EC subsidies for wind	Theme 1	Theme 2	Theme 3
No EC subsidies for wind	Theme 4	Theme 5	Theme 6
EC subsidies plus German subsidies	Theme 7	Theme 8	Theme 9

Reducing the Number of Scenarios: What is the Ideal Number of Scenarios?

As many as possible:

- To represent many views of the future;
- To represent many possibilities of the future.

As few as possible:

- Difficult to communicate results of many scenarios;
- No apparent upper limit to number of scenarios;
- The greater the number of scenarios, the more effort and resources needed for the scenario analysis.

Recommendation for strategic studies

Based on limitations of resources, and ability to communicate results of scenarios: 2 to 4

Steps in Scenario Development

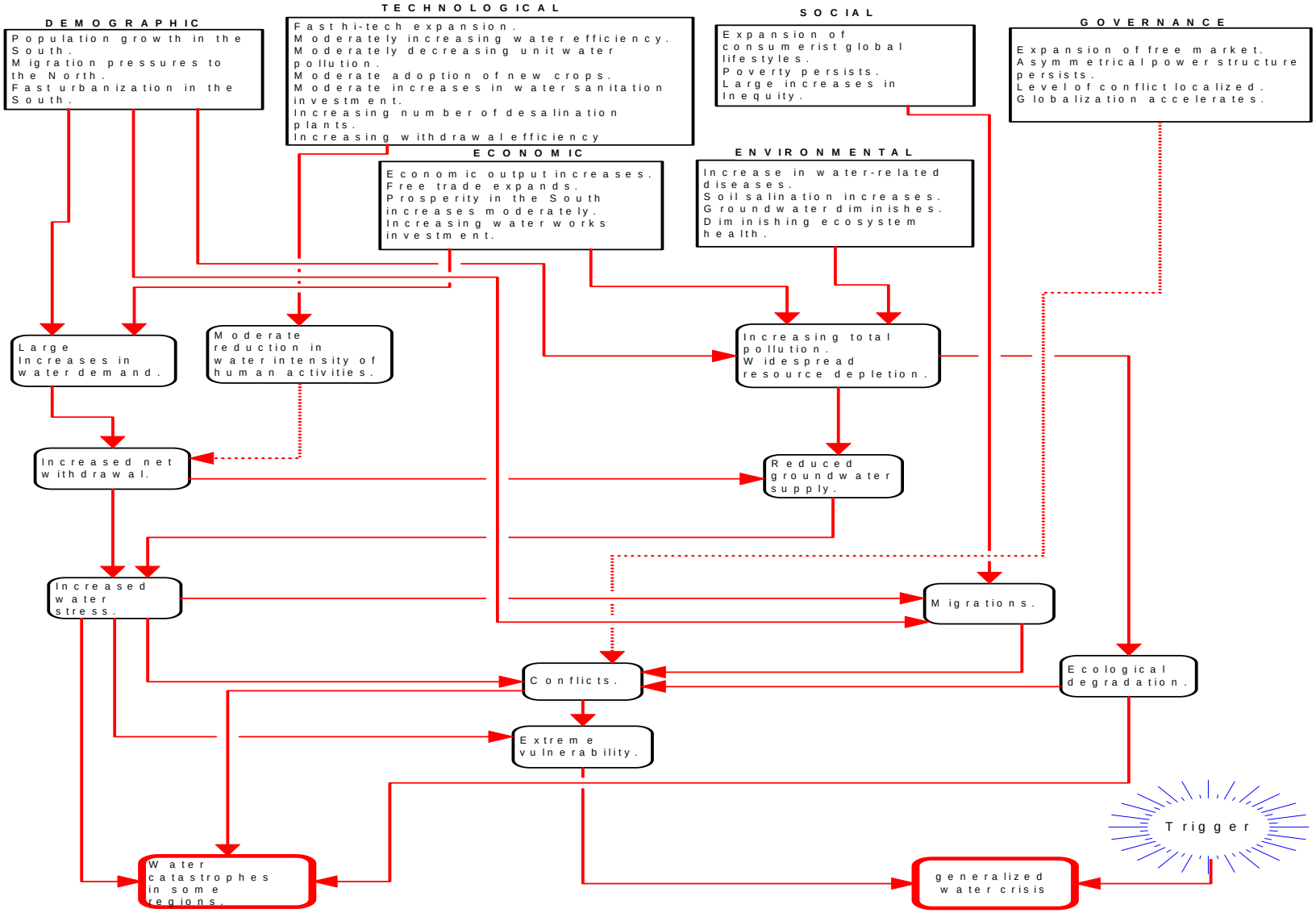
1. Select objectives and boundary conditions
2. Select themes
3. Select actors & factors
4. Develop mini-scenarios for each theme
5. Reduce number of mini-scenarios
6. **Write full scenarios – storylines**

Step 6. Write Full Scenarios -- Storylines

- Elaborate the mini-scenarios, step-by-step.
- Use “influence diagram”.
- Add “boxes” to communicate important or additional information.
- Use anecdotes/stories to illustrate main messages.

Step 6. Example – Influence Diagrams

Source: World Water Vision Scenarios (1999)



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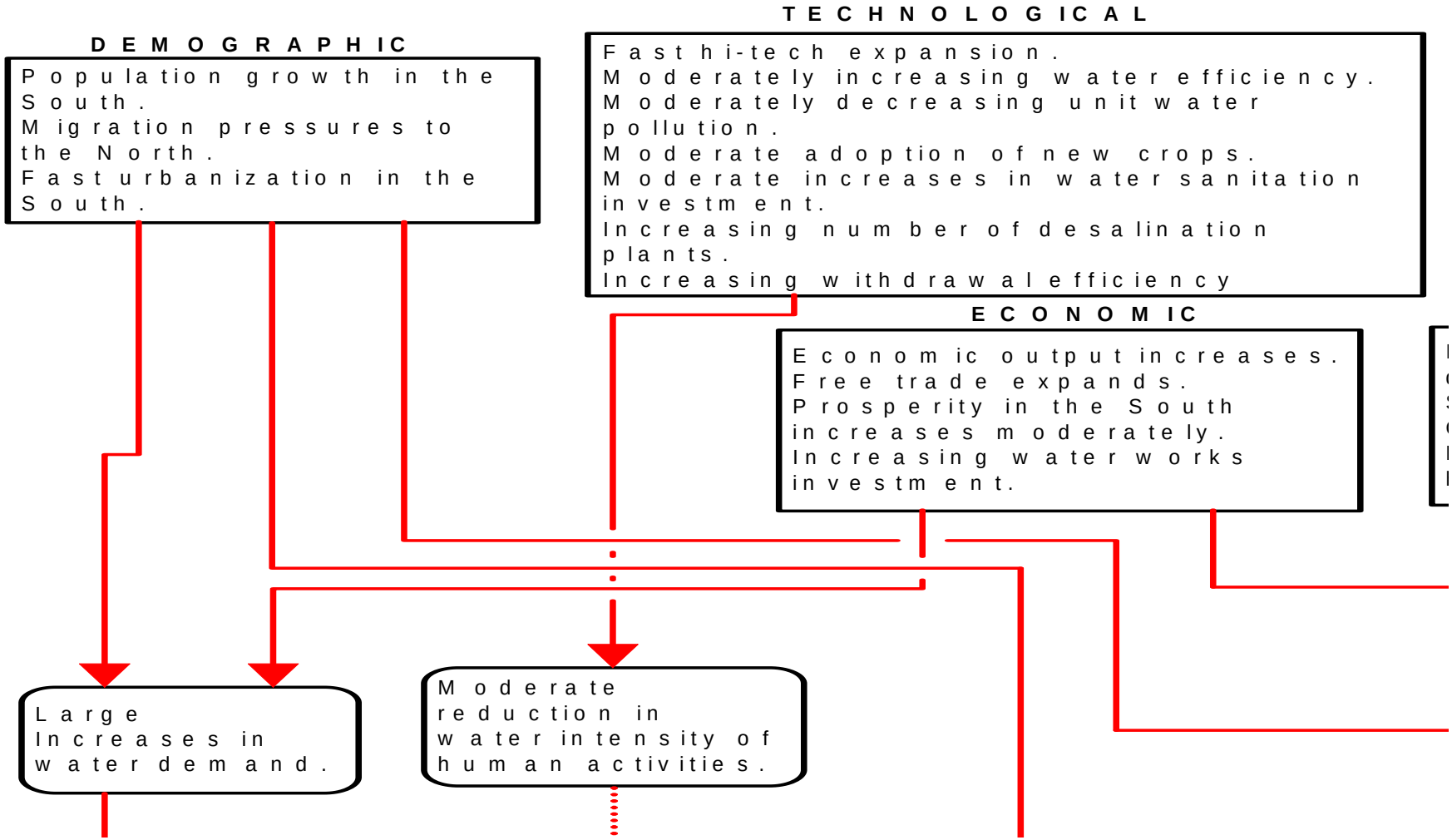

Step 6. Example – Boxes with Important Information

Source: IPCC-SRES Scenarios (2000)

Box 6-3 Main Findings and Implications of SRES Scenarios

- The four scenario families each have a narrative storyline and consist of 40 scenarios developed by six modeling groups.
- The 40 scenarios cover the full range of GHGs and SO_2 emissions consistent with the underlying range of driving forces from scenario literature.
- The 40 SRES scenarios fall into different groups – the three scenario families A2, B1, and B2, plus four groups within the A1 scenario family, two of which (A1C and A1G) have been combined into one fossil-intensive group A1FI in the Summary for Policymakers; see also footnote 2. The four A1 groups are distinguished by their technological emphasis – on coal (A1C), oil and gas (A1G), non-fossil energy sources (A1T), or a balance across all sources (A1).

Step 6. Example – Anecdotes/Stories

Source: IPCC-SRES scenarios (2000)

“ In the A1 scenario family, demographic and economic trends are closely related, as affluence is correlated with long life and small families (low mortality and low fertility) …

The global economy expands at an average annual rate of about 3% to 2100 … While the high average level of income per capita contributes to a great improvement in the overall health and social conditions of the majority of people, this world is not necessarily devoid of problems. … “

Summary: Elements of a Scenario

1. **A base year (or period)** and a description of the state of things in this year.
2. **A time horizon (or period) and time steps** – the end point in time of the scenario -- and a description of the state of things at that time.
3. **A geographic coverage** – the spatial coverage of the scenarios – city, country, global?
4. **A description of step-wise changes** – A description of the events between the base year and time horizon which explains how the future situation occurred from the present.
5. **Driving forces or uncertainties** – The main factors that influence the step-wise changes of the scenario.
6. **Storyline** – A narrative that presents the important aspects of a scenario, including the relationship between driving forces and events of the scenario.

Summary: Steps in Scenario Development

1. Select objectives and boundary conditions
2. Select themes
3. Select actors & factors
4. Develop mini-scenarios for each theme
5. Reduce number of mini-scenarios
6. Write full scenarios – storylines

Create your own future!