Scenario development

Concept and examples

Kasper Kok - Wageningen University, the Netherlands
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Scenario development in two lectures

Lecture 1 – Monday 22 August, 13:00-14:15
Background, overarching issues, concepts, definitions, tools
  • Complex Systems
  • Tools and methods to analyse complex systems
  • Scenarios

Lecture 2 – Wednesday 24 August, 10:15-11:30
Practical examples + conclusions
  • Exploratory scenario development – SAS approach
  • Group model building - Fuzzy Cognitive Maps
  • Normative scenario development - Backcasting

Conclusions
LECTURE 2

Scenario development

In practice
Content

Lecture 2: scenario development in practice
• Story-And-Simulation approach
• Fuzzy Cognitive Mapping
• Backcasting
A Project goal - exploration vs decision support:
I. Inclusion of norms? : descriptive vs normative
II. Vantage point: forecasting vs backcasting
III. Subject: issue-based, area-based, institution-based
IV. Time scale: long term vs short term
V. Spatial scale: global/supranational vs national/local

B Process design – intuitive vs formal:
VI. Data: qualitative vs quantitative
VII. Method of data collection: participatory vs desk research
VIII. Resources: extensive vs limited
IX. Institutional conditions: open vs constrained

C Scenario content - complex vs simple:
X. Temporal nature: chain vs snapshot
XI. Variables: heterogeneous vs homogenous
XII. Dynamics: peripheral vs trend
XIII. Level of deviation: alternative vs conventional
XIV. Level of integration: high vs low
EXAMPLE 1 - EXPLORATORY SCENARIOS

Example 1a - Qualitative and quantitative scenarios
Example 1b - Quantitative models
Example 1c - Qualitative scenarios
Example 1a:
The Millennium Ecosystem Assessment
(full Story-And-Simulation approach)
Millennium Ecosystem Assessment

An international scientific assessment of the consequences of ecosystem changes for human well-being:

- **Modeled on the IPCC**
- **Providing information requested by:**
  - Convention on Biological Diversity (CBD)
  - Convention to Combat Desertification (CCD)
  - Ramsar Convention on Wetlands
  - Convention on Migratory Species (CMS)
  - other partners including the private sector and civil society
- **With the goals of:**
  - stimulating and guiding action
  - building capacity
MA Conceptual Framework

Global
Regional
Local

Human Wellbeing & Poverty Reduction
- Health and disease
- Environmental security
- Cultural security
- Economic security
- Equity

Primary Drivers
- Demographic change
- Economic change (incl globalization, trade, market, & policy framework)
- Social and political change (incl governance, institutional, & legal framework)
- Technological change
- Lifestyle and behavioral change

Ecosystems & Their Services
- Supporting (biodiversity and ecosystem processes)
- Provisioning (food, water, fiber, fuel, other biological products)
- Cultural (social, aesthetic)

Life on Earth

Proximate Drivers
- Climate change
- Land and water use & cover change
- Factor inputs (e.g. irrigation, fertilizers)
- Pollution
- Harvest
- Nutrient release
- Species introductions

= Strategies and Interventions
Four global storylines

Proactive

Globally connected

Technogarden
Focus: Environmental technology

Adaptive Mosaic
Focus: Active learning

Reactive

Regional focus

Global Orchestration
Focus: Social policy

Order from Strength
Focus: Self interest

Approach to environmental management
Approach to quantifying the scenarios

Model Inputs
- Demographic
- Economic
- Technological

Model Outputs
- Provisioning Services
  - Food (meat, fish, grain production)
  - Fiber (timber)
  - Freshwater (renewable water resources & withdrawals)
  - Fuel wood (biofuels)

Regulating
- Climate regulation (C flux)
- Air quality (NOx, S emissions)

Supporting primary production

Storylines
- Global Orchestration, Techno-garden, etc.

AIM
- Global change

IMAGE
- Global change

WaterGAP
- World water resources

IMPACT
- World food production
Locations of Sub Global Assessments (SGAs).
17 Approved and 16 Associated SGAs.

- Coastal British Columbia, Canada
- Northern Lakes, Wisconsin
- Chirripo, Costa Rica
- Coffee-growing region, Colombia
- Vilcanota region, Peru
- Salar de Atacama, Chile
- Argentine pampas
- Southern Africa (SAfMA)
- Northern Range, Trinidad
- Caribbean Sea
- Portuguese
- Norway
- Stockholm and Kristianstad, Sweden
- Central Asia mountains
- Western China
- Laguna Lake Basin, Philippines
- Papua New Guinea small islands
- Fiji
- Altai-Sayan Ecoregion
- Downstream Mekong, Vietnam
- Arafura and Timor seas
- Northern Australia floodplains

Approved assessments
Associated assessments

Multi-scale assessments
Communicating scenarios: community theatre
Example 1b:

**EURURALIS**

Focus on models
Commissioned by the Ministry of Agriculture, the Netherlands

Jan Klijn, Teunis van Rheenen, Jan Bakkes, Henk Westhoek, Hans van Meijl, Tom Veldkamp, Maurits van den Berg, Bas Eickhout, Wies Vullings, Peter Verburg, Nynke Schulp, Nol Witte, Ron van Lammeren

RIVM & Wageningen UR, the Netherlands
EURURALIS: Methodology

Multi-scale modelling of scenarios of land use change

Multi-scale
- Address multi-scale characteristics of land use system dynamics
- Link global processes to local impacts
- Address different scales of policy discussions

Modelling
- Structured analysis
- Explore dynamics: ‘What-if…’
- Projections of future land use change

Scenarios
- Deal with uncertainty in development/policy
- Plausible futures
- No ‘desired’ future (no ‘doom or gloom’)
EURURALIS: Model chain

- **Storyline**
  - Global scenarios

- **GTAP/IMAGE**
  - Quantification of change in agricultural area at national level
  - Global economy and integrated assessment models

- **CLUE**
  - Visualisation of changes in landscape
  - Land allocation model

- **Indicators**
  - Quantification of impacts on "people, planet and profit" indicators
EU 25 arable and pasture land

EURURALIS: GTAP/IMAGE model
Example 1c:

**MedAction**

Focus on participation and storylines
Example 3: MedAction

Land use change scenarios at various scales

To better understand the driving forces leading to land degradation and desertification in the Northern Mediterranean and to contribute to policy-making to address these issues.
Main products of MedAction

- Scenarios 2000-2030
- Stakeholders
- Decision Support Systems

Policy Support Framework
Multi-scale scenario development

3 European Scenarios (from VISIONS)

3 Mediterranean Scenarios

Workshops with Local actors
Story of the present: Writing post-its
Three European scenarios

Convulsive Change

- Flooding
- Drought
- Desert formation

Information Technology dominates Inventions

Merger Mania

- Coca-Cola + Pepsi
- Shell + BP

Big is Beautiful

Knowledge is King
Creating the scenarios
The collages
Example project
**SCENES**: Water scenarios for Europe
Overall aim:
To develop and analyse a set of scenarios of Europe’s freshwater futures up to 2050, providing a reference point for long-term strategic planning; alert policy makers and stakeholders; and allow river basin managers to test water plans.
Story-And-Simulation approach

1. Establish scenario team and scenario panel
2. Team proposes goals and outline
3. Panel drafts narrative storylines
4. Team quantifies driving forces
5. Modelling groups quantify scenarios
6. Panel revises storylines
7. Repeat step 4-6
8. General review of scenarios
9. Team & Panel make final revision of scenarios
10. Publication and distribution
From scenarios to models

Fuzzy Cognitive Mapping: the missing link?

Narrative storylines → Quantified drivers → Model Runs

Fuzzy Cognitive Mapping
Fuzzy Cognitive Mapping
a semi-quantitative approach to participation
A Cognitive Map is the graphical representation of a system, where components are represented as boxes and relationships as arrows.

**Cognitive:** The Map is a cognitive interpretation of the system.

**Fuzzy:** The state of a system component is not exact but rather represented in a number of classes ('strong' or 'weak'), that are relative to each other.
1. *Gain insight in the system.* By incorporating multiple *feedbacks* that are difficult to reason through, new insights on the behaviour of the system can be acquired. (System)

2. *Gain insight in the perspectives of the stakeholders.* By using a semi-quantitative tool, *perspectives are made explicit.* (Perspectives)

3. *Stimulate mutual understanding.* By using FCM in a participatory setting, it can be used a tool to *deliberate and negotiate.* (Process)
Assume that $C_0$ and $C_2$ drive $C_1$.

Input vector:

\[
\begin{bmatrix}
1 \\
0 \\
1
\end{bmatrix}
\]

Assume relation:

- $C_0 \rightarrow C_1 + 1$
- $C_2 \rightarrow C_1 + 0.5$

Start Matrix:

\[
\begin{bmatrix}
1 & 1 & 0 \\
0 & 0 & 0 \\
0 & 0.5 & 1
\end{bmatrix}
\]
Assume that C0 and C2 drive C1

Input vector

\[
\begin{pmatrix}
1 \\
0 \\
1
\end{pmatrix}
\]

Assume extra relation:

\[
\begin{pmatrix}
1 & 1 & 0 \\
-0.1 & 0 & 0 \\
0 & 0.5 & 1
\end{pmatrix}
\]
FAU – hypothetical example IV

Assume that C1 drives itself:

\[
\begin{pmatrix}
1 & 1 & 0 \\
-0.1 & 0.9 & -0.1 \\
0 & 0.5 & 1
\end{pmatrix}
\]

Assume that C0 and C2 drive C1

Input vector

\[
\begin{pmatrix}
1 \\
0 \\
1
\end{pmatrix}
\]
FCM - Brazil example (graph)
FCM – Brazil example (dynamics)
FCM - Brazil example (link to resilience)
Participatory FCMs - creative process

Crimea - Ukraine

Guadiana - Spain
Participatory FCMs - structured consensus

Manaus - Brazil

Crimea - Ukraine
Participatory FCMs – group model building

Lower Tisza - Hungary

Lake Peipsi - Estonia
Participatory FCMs – dynamic output

Crimea – Ukraine

Manaus – Brazil
From FCM to model input
FCM – strong points

- **Easy to develop and apply.** The approach is highly intuitive, it can quickly be explained and applied to any new situation.
- **High level of integration.** A FCM can contain any type of information at any scale.
- **Forces users to be explicit** and facilitates a concrete discussion.
- **Easy insight on effect of impacts.**
- **Focus on feedbacks.** This explicit focus on feedbacks and non-linearities can uncover previously hidden key characteristics of the system.
FCM - weak points

• Relationships are only semi-quantified. It is difficult to interpret the output in absolute terms.

• Incomparable factors are compared. Comparing social, environmental, and institutional factors with equally weighted semi-quantitative measures is not always possible.

• Time is ill-defined. Factors included in the system do not usually all operate at the same temporal scale. FCM does not adequately deal with these time-mismatches.

When the focus is on participation:

• Too much attention on numbers. Discussion on weighing factors might hamper the creative process.

• Being concrete requires expert opinions. Especially when developing a FCM from scratch requires a high level of understanding of all participants.
Further reading

Kok, K. 2009. The potential of Fuzzy Cognitive Maps for semi-quantitative scenario development, with an example from Brazil. Global Environmental Change 19: 122-133


Kok, K. et al. In prep. Fuzzy Cognitive Maps as a tool to operationalise Competing Claims in Brazil.


Example project

SCENES: revisited
Scenarios: Exploratory and normative

Scenario development in four steps:
Step 1: agree on main drivers and uncertainties
Step 2: first-order draft of long-term, diverging storylines
Step 3: final draft with info from models
Step 4: create a set of short-term, converging strategies
Scenarios: Exploring and backcasting

Current situation
Plausible futures 2050 based on GEO-4

Exploring

Backcasting

Current situation
Short-term actions
Definition:

Backcasting “involves working backwards from a particular desired future end-point or set of goals to the present, in order to determine the physical feasibility of that future and the policy measures that would be required to reach that point.” (Robinson, 2003)

“The emphasis in backcasting is upon determining the freedom of action, in a policy sense, with respect to possible futures.” (Robinson, 2003)
Backcasting: background

AT&T in the 1950s proto-backcasting
Developed in the 1970s for business planning
First successful example Shell in scenario planning end 1970s
Current method developed by John Robinson in the mid 1980s; method has not fundamentally changed since
Robinson sees participative backcasting as the second generation of backcasting studies.

Typically address a perceived societal problem with the aim of finding a real solution \(\rightarrow\) normative
Recent examples of backcasting studies are all related to sustainable transport and/or energy.
Application in SCENES is innovative
Backcasting: background

Method bears similarities with SCENES overall method
(1. develop long-term visions; 2. do backcasting; 3. define action agenda and implementation)

Focus much less on forecasting, stories, and models
Forecasting part is usually 'only' a vision
Vision mostly has normative aspects
Backcasting: key concepts

Test how effective policy measures or other actions are, by evaluating them in a number of plausible futures.

Evaluate the plausibility of the storylines that have been used (can the future endstate envisioned in the story be reached with a set of concrete policy measures?)

Identify ultimately a set of (policy) actions that will lead to a more desirable future, independent from the future that is portrayed, i.e. that form a robust strategy.

In other words, translate 4 diverging long term scenarios to one set of robust policy actions.
A backcasting exercise consists of the following steps in group work:

1. Define a **desirable endpoint**
2. Define desirable intermediate **milestones and objectives**
3. Define **obstacles and opportunities** given the storyline that you find yourself in.
4. Iterate 2 and 3
5. Identify and specify **(policy) actions** that need to be taken
6. Iterate 2-5
A backcasting exercise consists of the following steps in plenary:

7. **Compare actions** across 4 scenarios and identify similarities and differences

8. **Construct a robust strategy** consisting of (policy) actions that are effective in a large number of backcasting exercises.
Example (hypothetical)
Example Cmap (Lower Tisza)

**Sustainability First Scenario**

- Positive feedback from locals
- Planning decisions
- Recognition of the interest of local population
- Financial and support for the operation of local floodplain management
- Design of floodplain systems (e.g., isolation of territories, solving issues affecting locals)
- The required investments get delivered on local level with government support
- The whole floodplain system operates

- Main motivations: environmental consciousness, decentralized systems, transparency, democracy, ecotechnologies, need for landscape rehabilitation

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**2013**

- Improvement of the Water Management Plan (accepted in 2013)
- Promotes the floodplain approach over new storage systems
- Lobby (professional remarks are forwarded to political decision makers)
- The modification of policies is required
- Sufficient sources are available for the operation of the systems

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**2014**

- The entire sewer treatment system is delivered
- The funding is available for the leasing of the infrastructure system
- Sufficient funding is available for operational and maintenance costs

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**2015**

- Start of design (ecological treatment technologies suitable to local circumstances), delivery of treatment systems
- Sufficient awareness forming at both of the target groups, cooperation of the decision makers and the people affected
- Measurement of the diffuse pollution related to agriculture
- Intergovernmental treaty for the Danube region and the Tisza
- Intergovernmental strategy for the Danube region and the Tisza

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**2016**

- Quantity of pollution leaving the big and small communities is minimal
- Pollution reaching the Hungarian Tisza section is minimal
- Pollution arising from upstream countries (Ukraine, Romania) are marginal
- Limited operation, maintenance of the areas (e.g., channel cleaning), monitoring and feedback
- The water balance of the Hungarian section of the Tisza is not negative

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**2017**

- Get the high and dry regions to fall into line with the most developed ones in terms of infrastructure
- Decrease in pollution
- Universal operation, maintenance of the areas (e.g., channel cleaning), monitoring and feedback
- The water balance of the Hungarian section of the Tisza is not negative

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**2018**

- Preparation for the negotiations with the countries on the Tisza watershed for minimizing the pollution.
- Sustainable regulation of policy support
- International regulations, allocation of funding, changing of approach

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**2019**

- Intergovernmental treaty for the Danube region and the Tisza
- Sustainable regulation of policy support

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**2020**

- Pollution reaching the Hungarian Tisza section is minimal
- Pollution arising from upstream countries (Ukraine, Romania) are marginal
- Pollution reaching the Hungarian Tisza section is minimal

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**2021**

- The entire sewer treatment system is delivered
- The funding is available for the leasing of the infrastructure system
- Sufficient funding is available for operational and maintenance costs

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**2022**

- The entire sewer treatment system is delivered
- The funding is available for the leasing of the infrastructure system
- Sufficient funding is available for operational and maintenance costs

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**2023**

- The entire sewer treatment system is delivered
- The funding is available for the leasing of the infrastructure system
- Sufficient funding is available for operational and maintenance costs

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Conclusions (methods)

• Interdisciplinarity
  Conceptually: always consider multiple disciplines
  Practice: be T-shaped (expertise on certain aspect)

• Multi-scale
  Conceptually: always think multi-scale
  Practice: only when specific research question is multi-scale

• Participation
  Only when specific research questions asks for stakeholder involvement
Conclusions (the role of scenarios)

• Scenarios are crucial in understanding and structuring uncertainty, and therefore in addressing complex problems

• Scale issues are considered but not particularly upscaling of local scenarios deserves more attention

• Scenarios are usually integrated, but the domination of environmental sciences is worrying

• Most exercises include stakeholders

• Models and qualitative products are increasingly combined
Conclusions (tools)

• Models (quantitative scenarios)
  Is an excellent tool, but realise the limitations in flexibility, data availability, involvement of non-experts

• Scenarios (qualitative storylines)
  Is an excellent tool with growing interest, but realise limitations in quantitative results.

• Story-And-Simulation (models and narratives)
  Very resource demanding (time and money). This is normally impossible in any smaller project.
  A growing set of tools is becoming available to maintain level of creativity and diversity without sacrificing structure and exactness
Conclusions (postmodern science)

• We have developed a large number of tools, methods, and approaches

• We have very little knowledge of the actual impact of scientific work. In terms of scenarios, we need to focus research on the scenario quality indicators, particularly
  o Legitimacy (do justice to a wide range of ideas and perspectives)
  o Credibility (recognisable from the present and how plausible is it?)
  o Relevance (to end users; are concerns addressed?)
Background information

Example 1a: www.millenniumassessment.org
Example 1b: www.eururalis.eu; www.cluemodel.nl
Example 2&3: www.environment.fi/syke/scenes

Further reading:
Kok, K. 2009. The potential of Fuzzy Cognitive Maps for semi-quantitative scenario development, with an example from Brazil. Global Environmental Change 19: 122-133


Questions?