# The simplification of complexity: challenges of sustainability science for governance

Significant Digits: Responsible Use of Quantitative Information
Brussels, June 10th 2015

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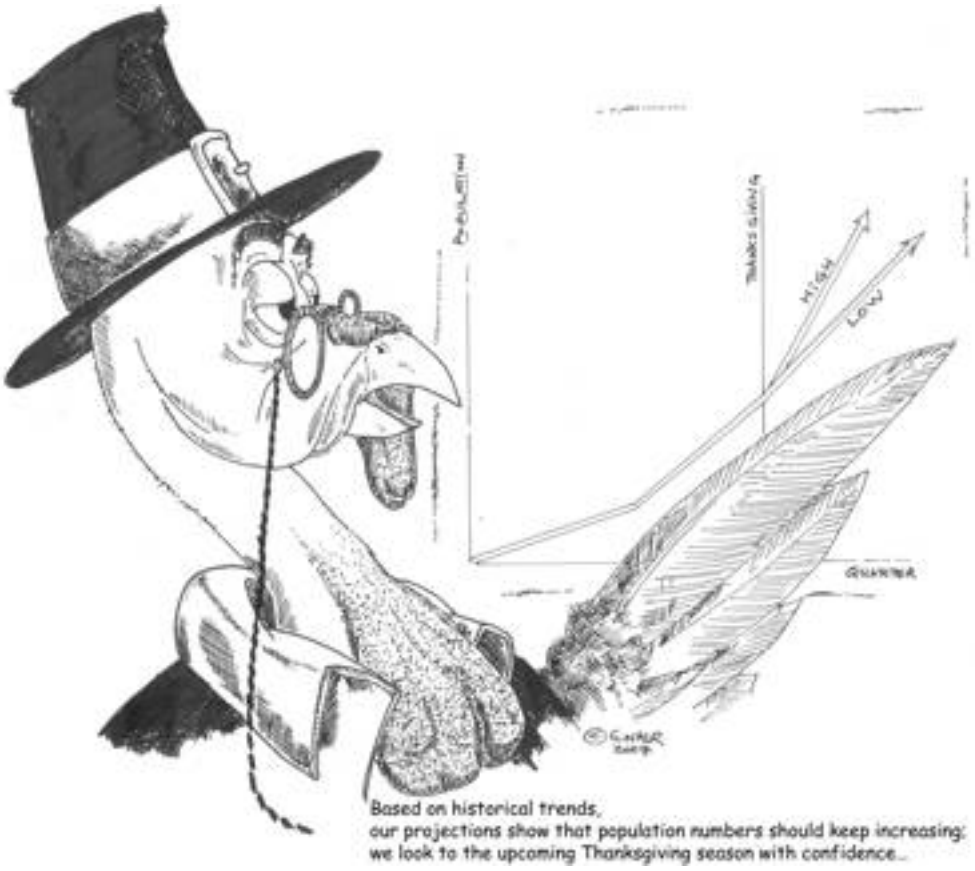
# This talk…

How useful is quantitative evidence?

Should policy be based on evidence?

Responsible use of quantitative information

# How useful is quantitative evidence?




"Based on historical trends, our projections show that population numbers should keep increasing: we look to the upcoming Thanksgiving with confidence…"

"Deep understanding and predictive ability are decoupling as we speak"

Idan Michaeli,
Lead Data Scientist

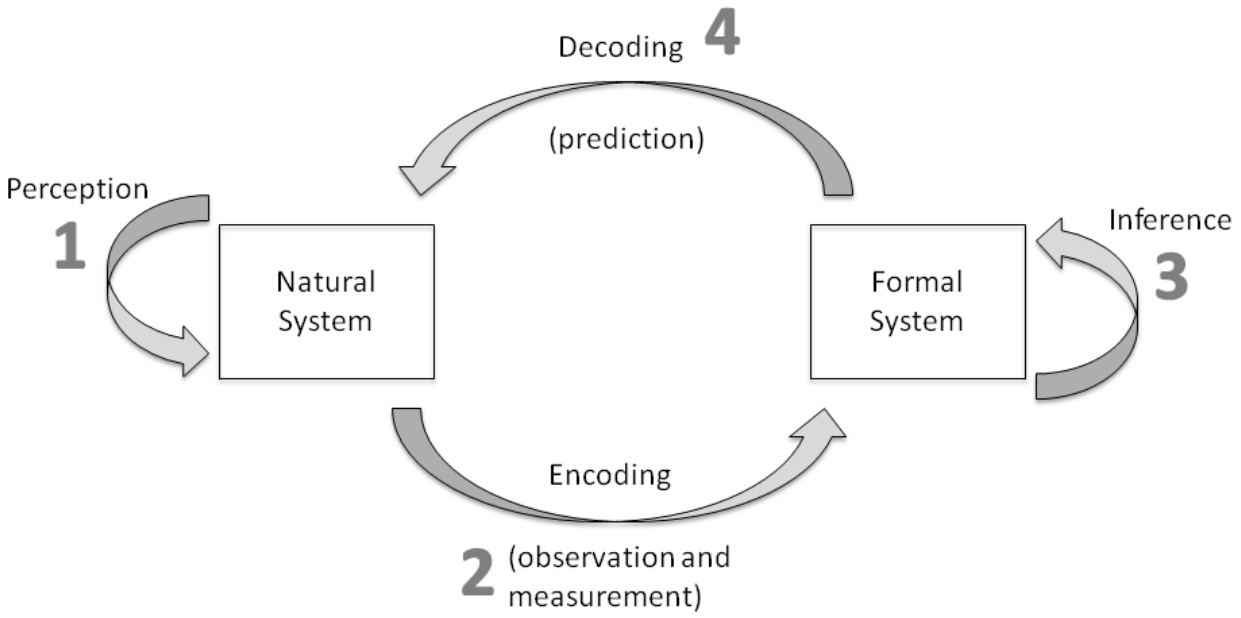
# Evidence based policy

- Science speaking truth to power
- Whose truth?

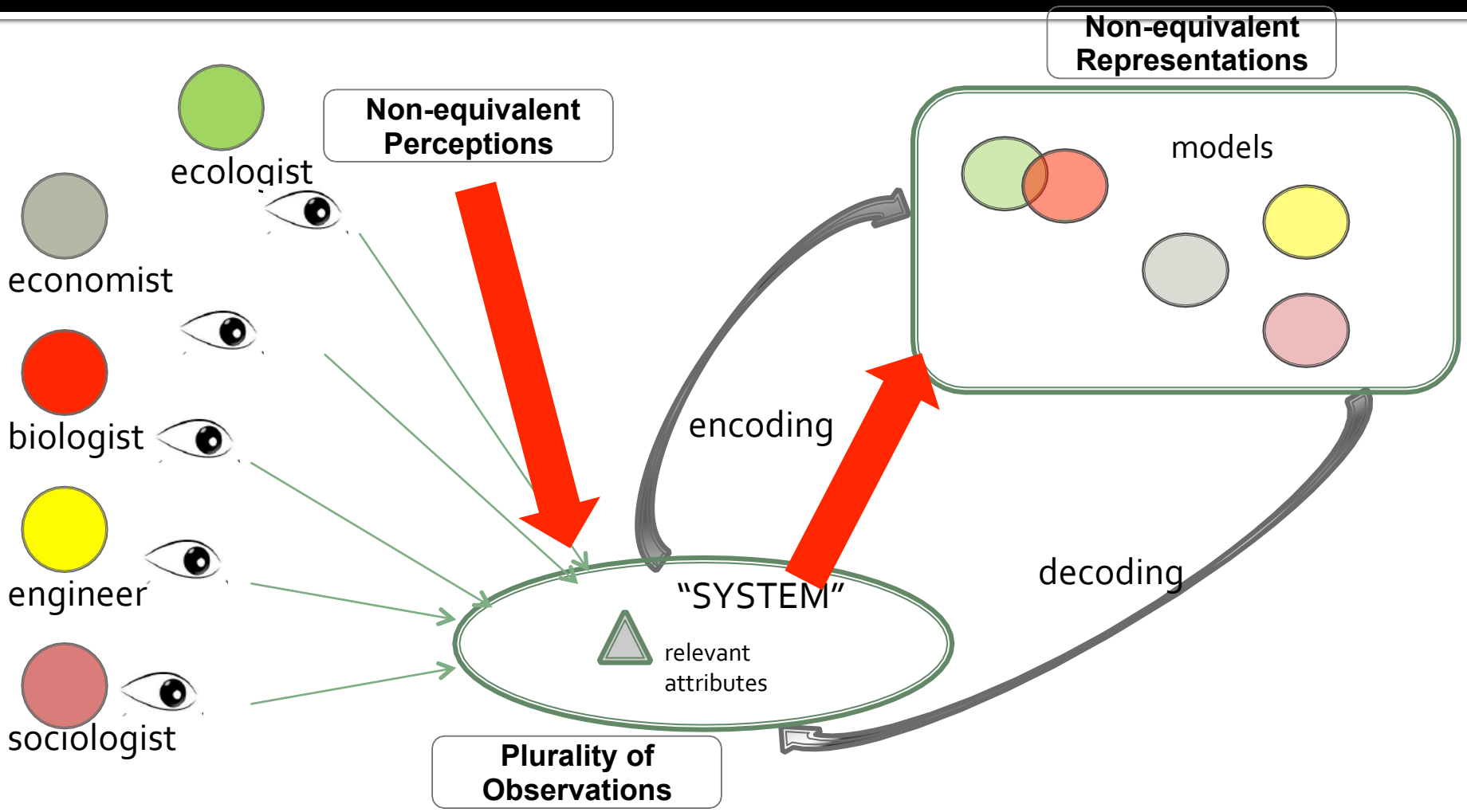
# Many voices of science

- Climate change
- Nuclear power
- GMOs
- Biofuels
- Peak oil

# Rosen's modelling relation



# Narratives, perceptions and representations




Source: Kovacic and Giampietro 2015

# The case of "Beyond GDP" indicators

| Indicator | Scale of Anal | Descriptive do | Measurement scheme |
|---|---|---|---|
| GDP | The | Econ | Monetary valuation of oductive activities |
| Net Savings | The econon | Economics | Disposable wealth net of public expenditure |
| Happiness Index | ndividual | ology | Qualitative subjective self-evaluation |
| Health | The | Medicine | Average life expectancy |
| Ecological footprint | ecosystem | Ecology | $CO_2$ emissions in land use equivalent |

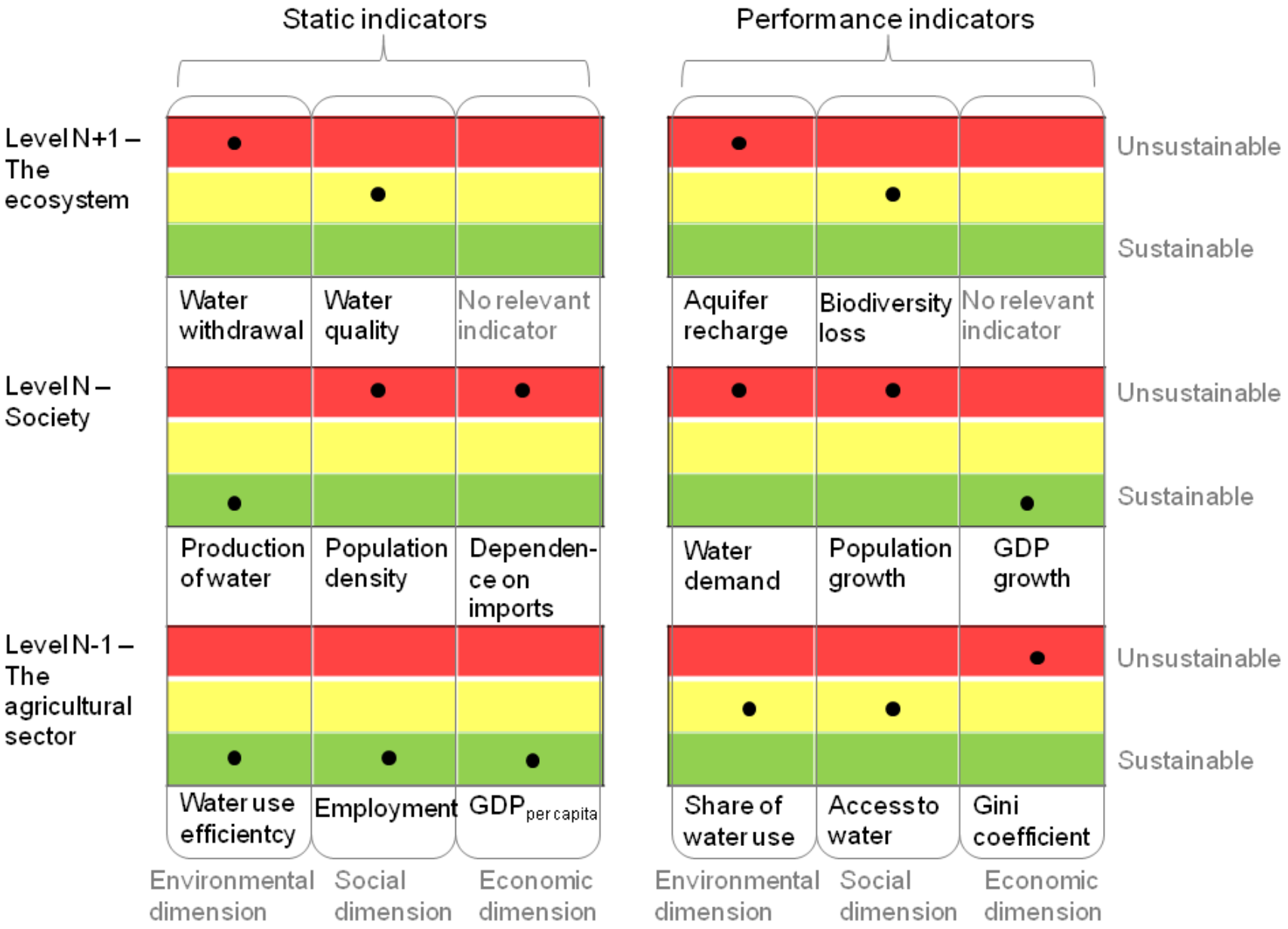
WHICH INDICATOR SHOULD BE USED?

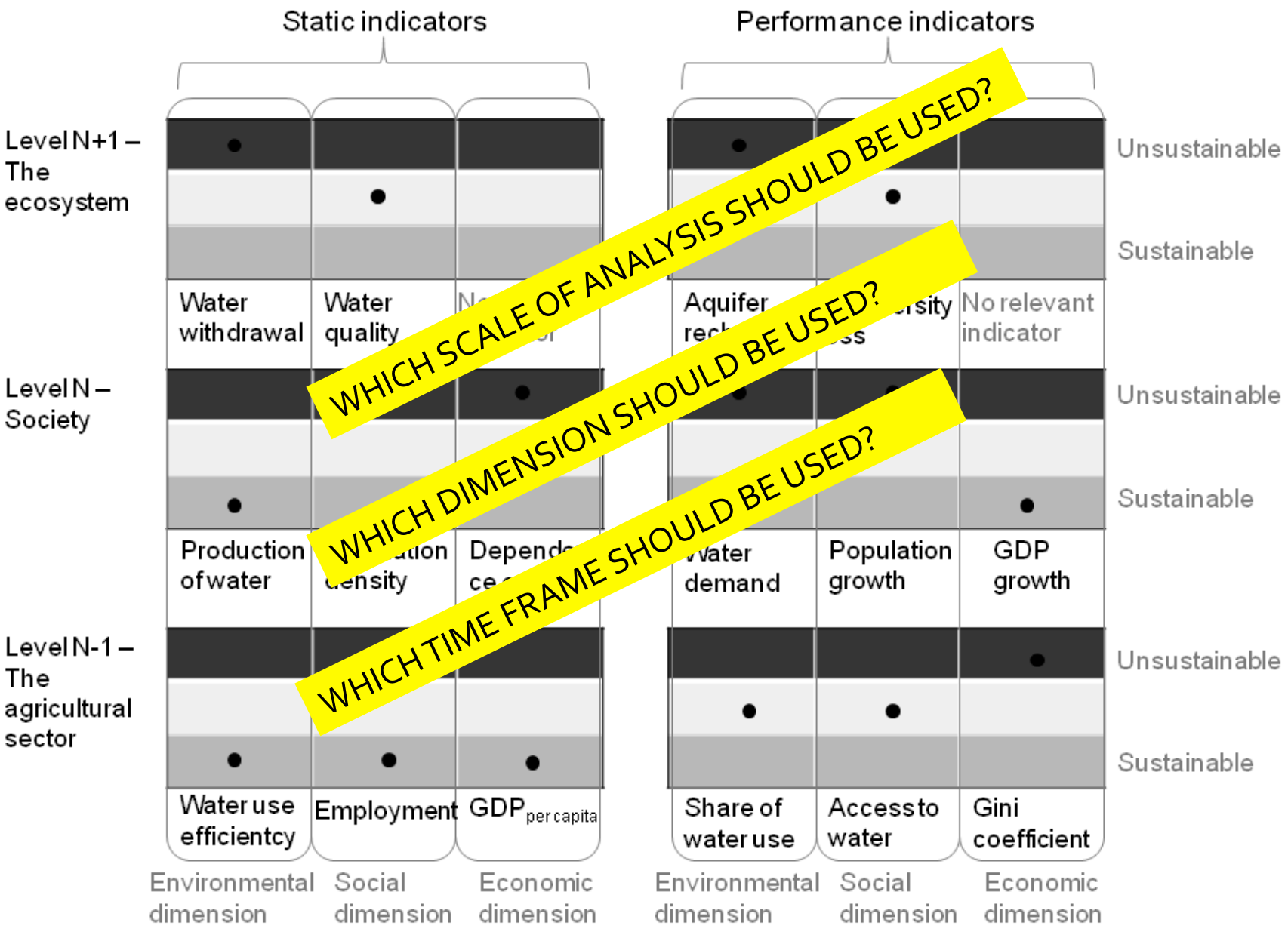
WHICH NARRATIVES ARE REPRESENTED?

WHICH NARRATIVES ARE IGNORED?

# The case of water

- The Israeli government sees water as a **scarce resource** that is crucial to maintain living standards and ensure the well being of the population
- Water scarcity has prompted the adoption of probably the most **efficient water systems** in agriculture and an unparalleled level of innovation in the country, ranging from drip irrigation, grey water recycling in agriculture, all the way to the development of sea-water resistant crops
- Water has been taken also as the explanatory factor for **conflicts in the Middle East**
- and within Israel and **Palestine**
- Zionist water experts argued that **water resources were abundant** in order to encourage open immigration of Jews into the country.


Static indicators
Performance indicators
Level N+1 – The ecosystem
Level N – Society
Level N-1 – The agricultural sector
Unsustainable
Sustainable
Unsustainable
Sustainable
Unsustainable
Sustainable
Water withdrawal
Water quality
No relevant indicator
Aquifer recharge
Biodiversity loss
No relevant indicator
Production of water
Population density
Dependen-ce on imports
Water demand
Population growth
GDP growth
Water use efficientcy
Employment
GDP per capita
Share of water use
Access to water
Gini coefficient
Environmental dimension
Social dimension
Economic dimension
Environmental dimension
Social dimension
Economic dimension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Economic dimension
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Social dimension
Economic dimension
WHICH SCALE OF ANALYSIS SHOULD BE USED?
WHICH DIMENSION SHOULD BE USED?
WHICH TIME FRAME SHOULD BE USED?

# Should policy be based on evidence?

# The use of science for governance

- How sensitive to data are policies?
- How refined do the data need to be to be useful for policy?

# GDP will resume growth in 2009

***...although solid fundamentals limit the downward revision***

The Commission's baseline forecast assumes that the turbulence will peter out gradually, although with a reduction in investors' appetite for risk and tighter financing conditions as a result. This would have a certain adverse effect on investment and consumption growth, which could be reinforced by wealth and confidence effects. However, a still benign global environment, high profit margins, confidence indicators remaining above their long-term averages, continued employment growth in the EU and, in some cases, expansionary fiscal policies suggest that growth should hold up reasonably well. Real GDP growth is therefore expected to decelerate from 2.9% this year to 2.4% in both 2008 and 2009 in the EU (and in the euro area from 2.6% in 2007 to 2.2% in 2008 and 2.1% in 2009), close to potential growth. This constitutes a downward revision of 0.3 of a percentage point (pp.) in 2008 for both areas compared to the spring forecast.

European Commission, Economic Forecast, autumn 2007. Directorate-General for Economic and Financial Affairs, European Economy, No. 7/2007

# GDP will resume growth in 2010

The EU and euro-area economies at a stand-still next year...

GDP growth, thus, is expected to come to a stand-still in 2009 in both the EU and the euro area, implying a downward revision of about 1½ pps. since the spring forecast. Several EU countries are forecast to experience a technical recession, i.e. two consecutive quarters of negative quarter-on-quarter (q-o-q) growth. Some countries will be subject to more pronounced downturns and/or lasting corrections reflecting their exposure to the shocks above and to other country-specific factors. For 2010, a slow recovery is thus foreseen for most, but not all, economies suggesting an acceleration of GDP growth to about 1% in both regions.

European Commission, Economic Forecast, autumn 2008. Directorate-General for Economic and Financial Affairs, European Economy, No. 6/2008

# GDP will resume growth in 2011

Growth gradually picking up

Overall, after the temporary boost expected during the second half of this year, real GDP growth is expected to ease somewhat and to regain ground only by the second half of next year. As both external and domestic demand gradually strengthen, growth could recover to about 0.5% quarter-on-quarter (q-o-q) during 2011 in both the EU and the euro area. Taking into account the weak carry-over from this year, annual growth rates will be limited to about ¾% in 2010 in both regions. The following year, GDP could grow by some 1½%, thereby starting to gradually close the output gap that will have opened up by then as a result of the crisis.

European Commission, Economic Forecast, autumn 2009. Directorate-General for Economic and Financial Affairs, European Economy, No. 10/2009

# GDP will resume growth in 2012

## Autumn forecast 2010-2012: EU recovery taking hold, but progress uneven

***The European Commission's autumn forecast foresees a continuation of the economic recovery currently underway in the EU. GDP is projected to grow by around 1¾% in 2010-11 and by around 2% in 2012. A better than expected performance so far this year underpins the significant upward revision to annual growth in 2010 compared to the spring forecast. However, amid a softening global environment and the onset of fiscal consolidation, activity is expected to moderate towards the end of the year and in 2011, but to pick up again in 2012 on the back of strengthening private demand. With the economic recovery taking hold in the EU, labour-market conditions are expected to slowly improve over the forecast horizon, as is the budgetary situation. The unemployment rate is projected to fall to around 9% in 2012, with the public deficit declining to about 4¼% of GDP. Developments across Member States are nevertheless set to remain uneven.***

European Commission, Economic Forecast, autumn 2010. Directorate-General for Economic and Financial Affairs, European Economy, No. 7/2010

# GDP will resume growth in 2013

... the growth forecast for 2012 has been revised down substantially.

Expected GDP growth is revised down for the second half of this year as well as for 2012; for 2013, a return of modest growth is projected. Mostly due to the strong GDP growth in the first quarter of this year, annual GDP growth for 2011 remains close to the values projected in the spring forecast, at 1.6% in the EU and 1.5% in the euro area. Growth for 2012 is revised down substantially, by 1¼ percentage points to ½% in both the EU the euro area. For 2013, annual growth is projected at 1.5% in the EU and 1.4% in the euro area. In terms of quarterly profile, growth is expected to be nil in the fourth quarter of 2011. On account of a gradual return of confidence and abating external drag, quarterly GDP growth is then expected to slowly increase to around 0.4% in both the EU and the euro area by the fourth quarter of 2012. This modest level of quarterly growth is forecast to be maintained throughout 2013.

European Commission, Economic Forecast, autumn 2011. Directorate-General for Economic and Financial Affairs, European Economy, No. 6/2011

# GDP will resume growth in 2014

A slow recovery has set in

The EU economy has returned to positive GDP growth. Following a slow and still vulnerable expansion of economic activity during the remainder of 2013, growth is set to become gradually more domestic demand-driven and more robust in the course of 2014 and into 2015. The legacy of the crisis – deleveraging, financial fragmentation, elevated uncertainty and rebalancing needs – will continue weighing on growth. Its impact is however expected to gradually subside over the forecast horizon as progress is made with the correction of the accumulated macroeconomic imbalances, and domestic demand is expected to take over as the main engine of growth. External demand is expected to pick up over the coming quarters, but less than earlier expected, on account of a weakened outlook for growth in emerging market economies and the appreciation of the euro. Reflecting the carry-over from the weakness of economic activity last winter, GDP in annual terms is expected to remain unchanged in the EU and contract by ½% in the euro area in 2013. Next year, economic activity is projected to expand by 1½% in the EU and 1% in the euro area before accelerating to 2% and 1¾%, respectively,

European Commission, Economic Forecast, autumn 2013. Directorate-General for Economic and Financial Affairs, European Economy, No. 7/2013

| Euro Area (18 countries) | Eurostat | EC Forecast, abs. average error 2.5 pts (170%) |
|---|---|---|
| 2009 | -4.8 | 2.1 error=6.9 |
| 2010 | 1.7 | 1 error=0.7 |
| 2011 | 1.3 | 1.5 error=0.2 |
| 2012 | -0.9 | 2 error=1.1 |
| 2013 | -0.6 | 1.4 error=2.0 |

| EU (28 countries) | Eurostat | EC Forecast, abs average error 2.4 pts (140%) |
|---|---|---|
| 2009 | -4.8 | 2.4 error=7.2 |
| 2010 | 1.7 | 1 error=0.7 |
| 2011 | 1.4 | 1.5 error=0.1 |
| 2012 | -0.7 | 2 error=2.7 |
| 2013 | -0.1 | 1.5 error=1.6 |

Eurostat http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&plugin=1&language=en&pcode=tsdec100

# Why keep predicting?

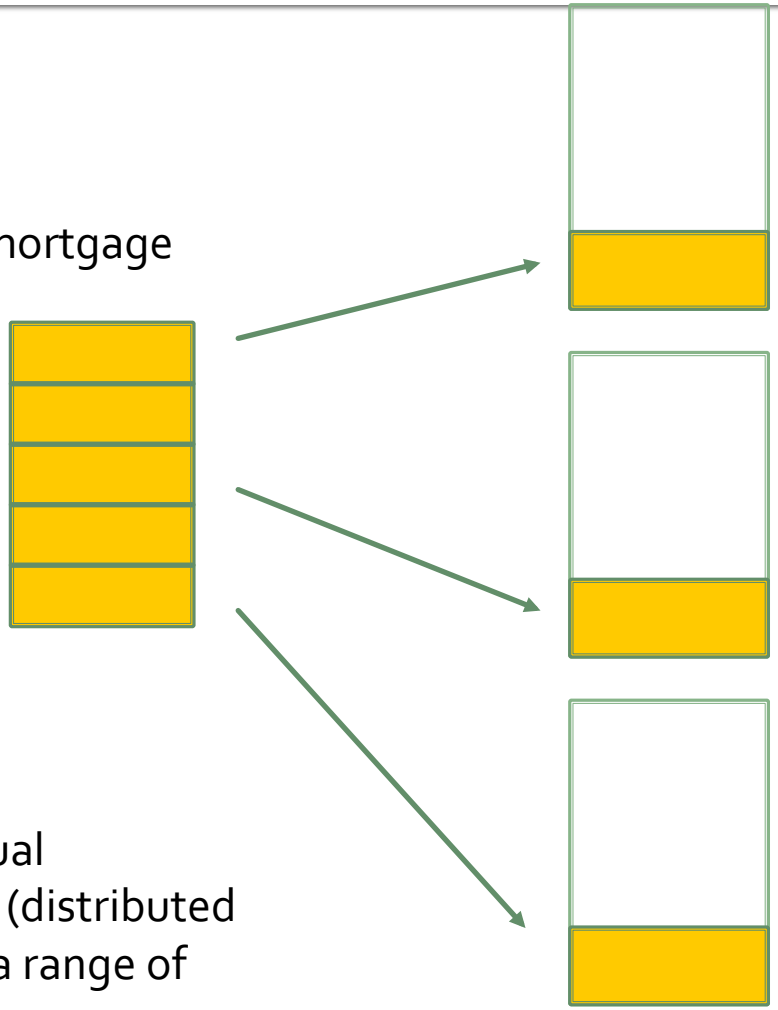
Experience during World War II as a weather forecaster added the news that the natural world as also unpredictable. An incident illustrates both uncertainty and the unwillingness to entertain it. Some of my colleagues had the responsibility of preparing long-range weather forecasts, i.e., for the following month. The statisticians among us subjected these forecasts to verification and found they differed in no way from chance. The forecasters themselves were convinced and requested that the forecasts be discontinued. The reply read approximately like this: **'The Commanding General is well aware that the forecasts are no good. However, he needs them for planning purposes.'** *Kenneth Arrow, 1992.*

# Forecasts have a mean reverting core

# When numbers do not matter…

# The mechanism – loan pooling

Sub-prime mortgage



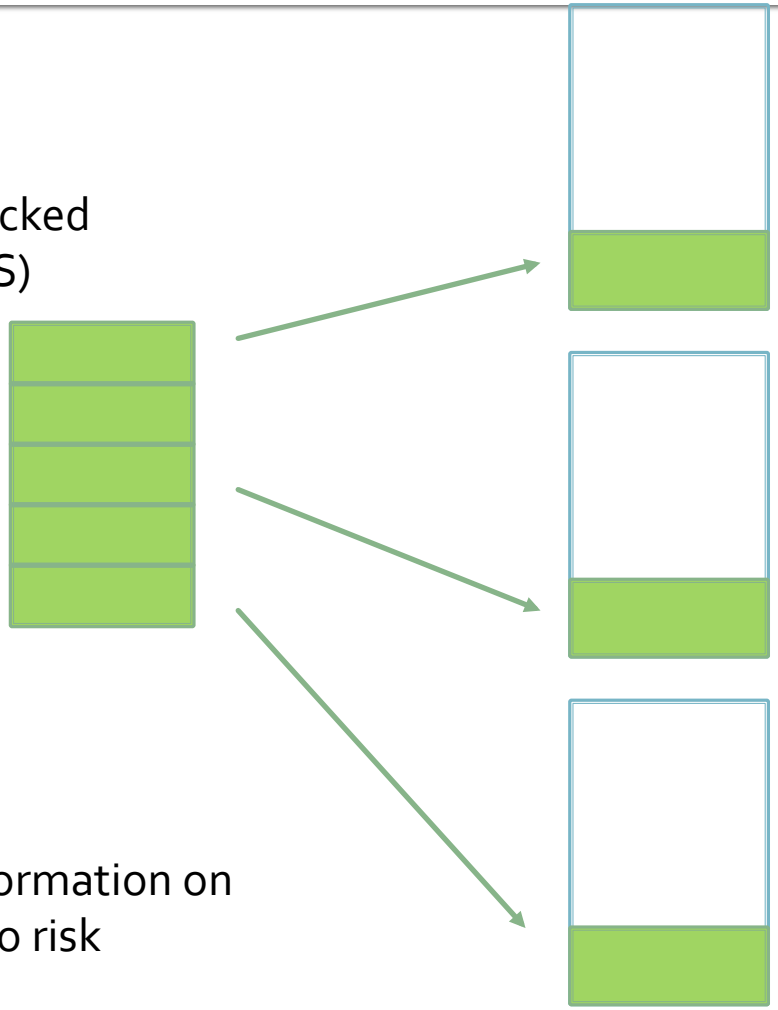
Mortgage backed security (MBS)

The risk of the individual investment is reduced (distributed in smaller portions to a range of securities)

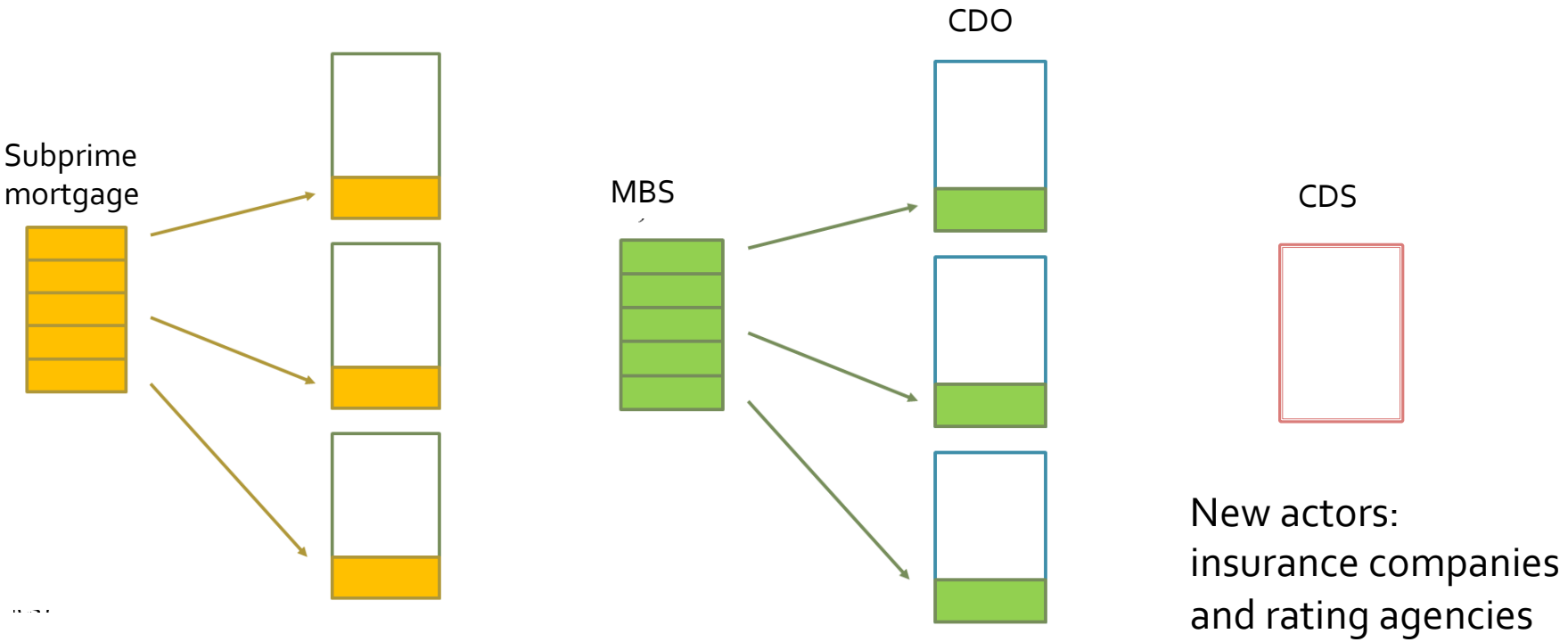
# The mechanism – securitisation

Collateralised debt obbligation (CDO)

Mortgage backed security (MBS)

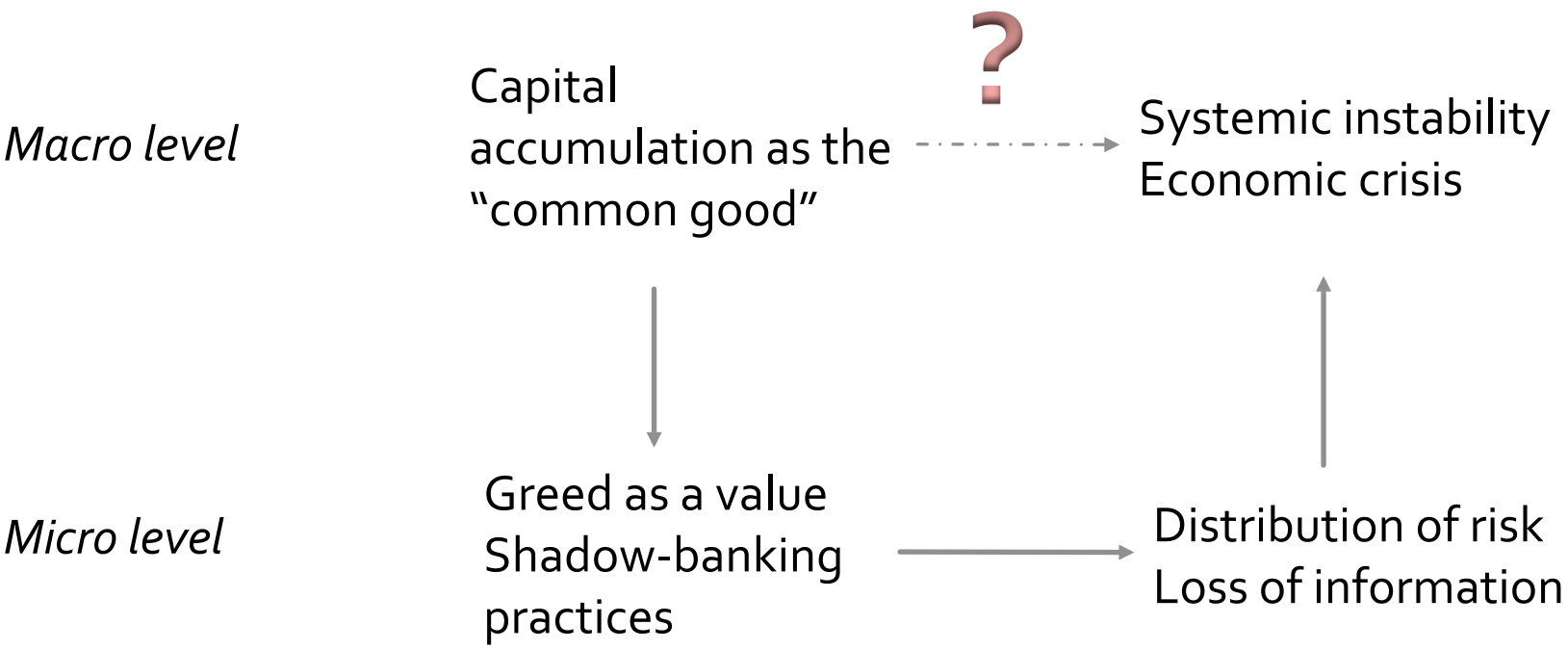


Progressive loss of information on location and amount fo risk



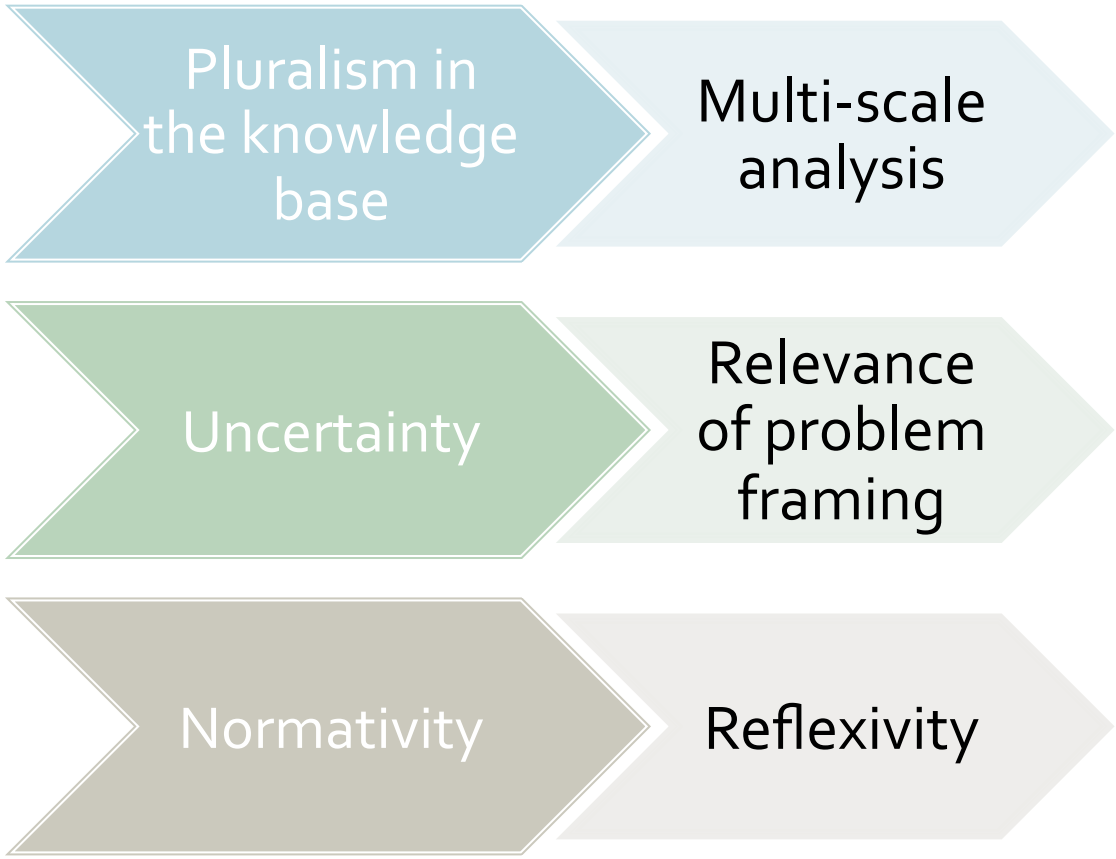

➔ Rational choices at the individual level led to distribution of risk to entire financial sector and systemic loss of information

# Transmission mechanism



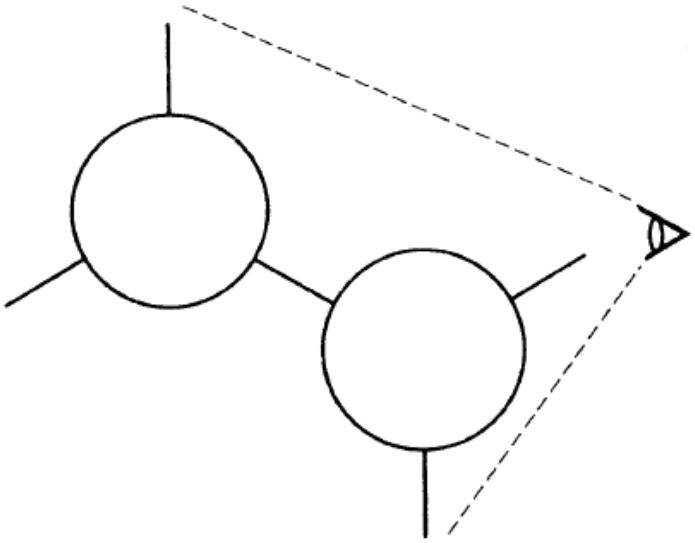
# Responsible use of quantitative information

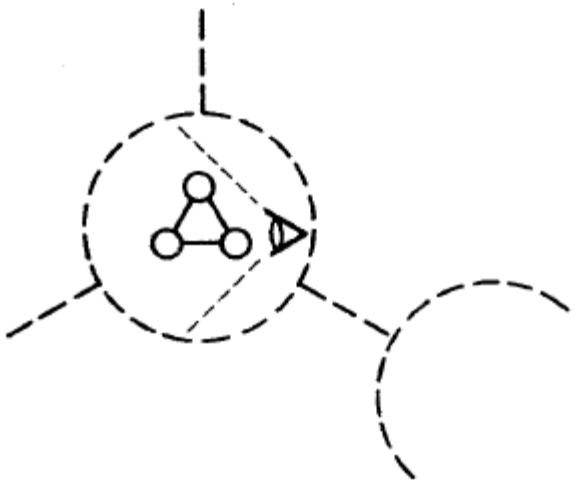
# Analytical tools



# Scales of analysis

- Level of analysis
- Level of observation





Allen et al. 1984

# How can this tool be used?

- Make sense of multiple knowledge claims
- Identify the limits of a representation
- Identify knowledge gaps

Multi-scale analysis

Event: THE DEATH OF A PARTICULAR INDIVIDUAL

EXPLANATION 1 --> “no oxygen supply in the brain”

*Space-time scale*: VERY SMALL *Example*: EMERGENCY ROOM

*Implications for action*: APPLY KNOWN PROCEDURES

*Based on known HOW - past affecting strongly present actions*

EXPLANATION 2 --> “affected by lung cancer”

*Space-time scale*: SMALL *Example*: MEDICAL TREATMENT

*Implications for action*: KNOWN PROCEDURES & EXPERIMENTATION

*Looking for a better HOW - past affecting present, but room for change*

EXPLANATION 3 --> “individual was a heavy smoker”

*Space-time scale*: MEDIUM *Example*: MEETING AT HEALTH MINISTRY

*Implications for action*: MIX EXPERIENCE AND WANTS INTO POLICY

*Considering HOW and WHY - past and “virtual future” affecting present*

EXPLANATION 4 --> “humans must die”

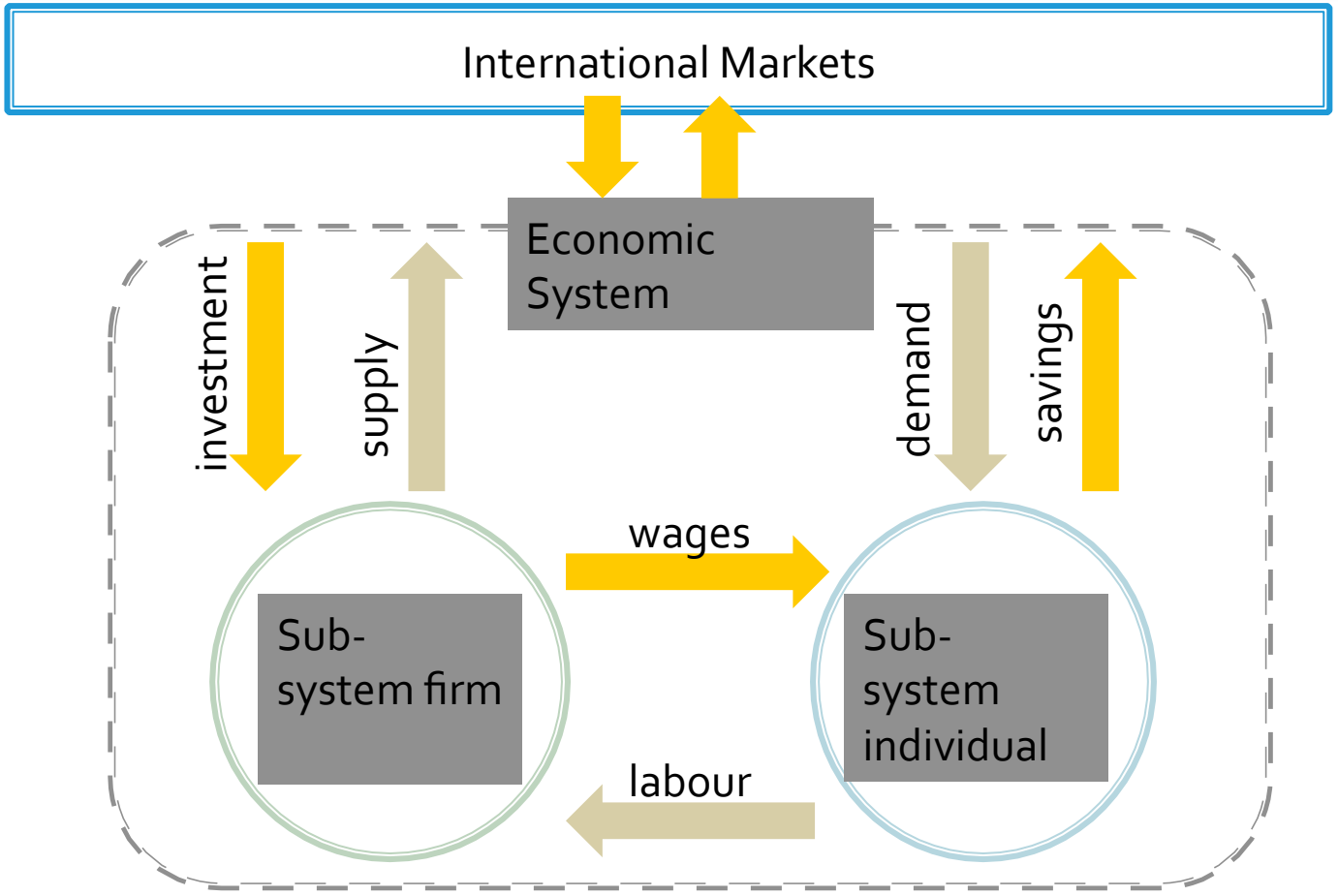
*Space-time scale*: VERY LARGE *Example*: SUSTAINABILITY ISSUES

*Implications for action*: DEALING WITH THE TRAGEDY OF CHANGE

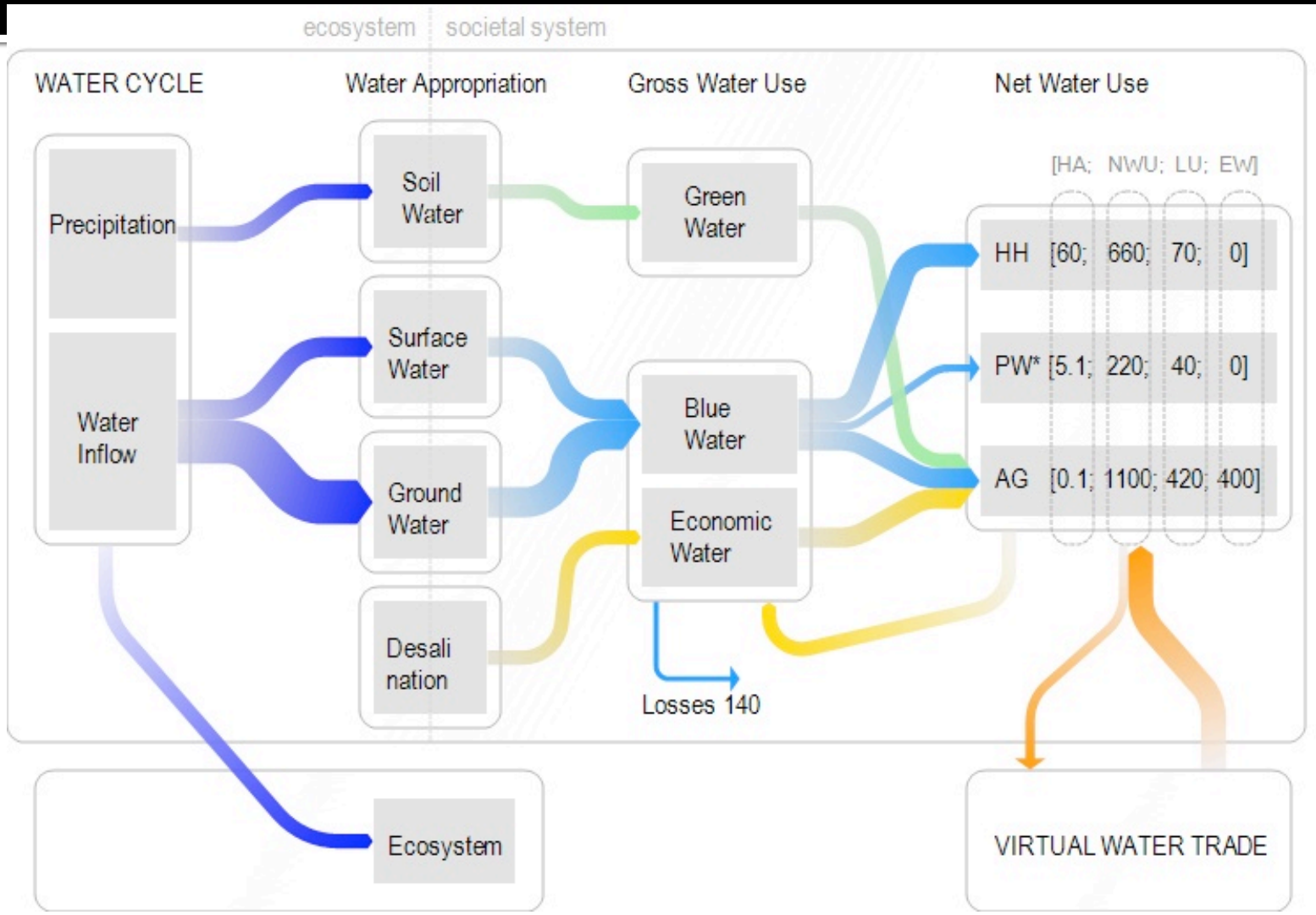
*Considering WHY - “virtual future” (values) affecting present*

Slide borrowed from Mario Giampietro

# The economy as a complex system

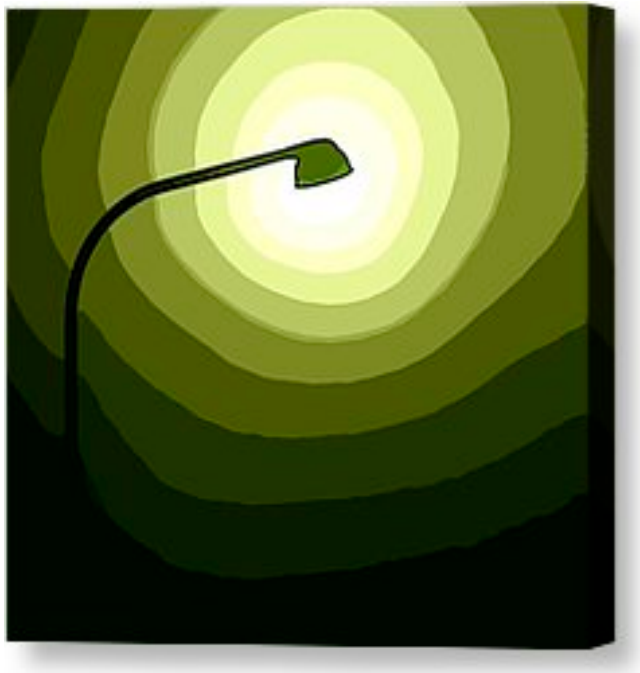


# Multiple scales of analysis for water



# Uncertainty

- Hypocognition (Lakoff 2010)
- Cognitive ease and biases (Kahneman 2011)



# Quantifying ecosystem instability

## Kinneret Water Level

Water levels in the Kinneret fluctuate, depending on precipitation and inflow, as well as the on the amount of water pumped out to consumers.

The minimum and maximum levels of the Kinneret are set in regulations that were passed in 1967 (Regulation of Water Level) and in the 1968 Water Order (Determining Allowable Water Level).

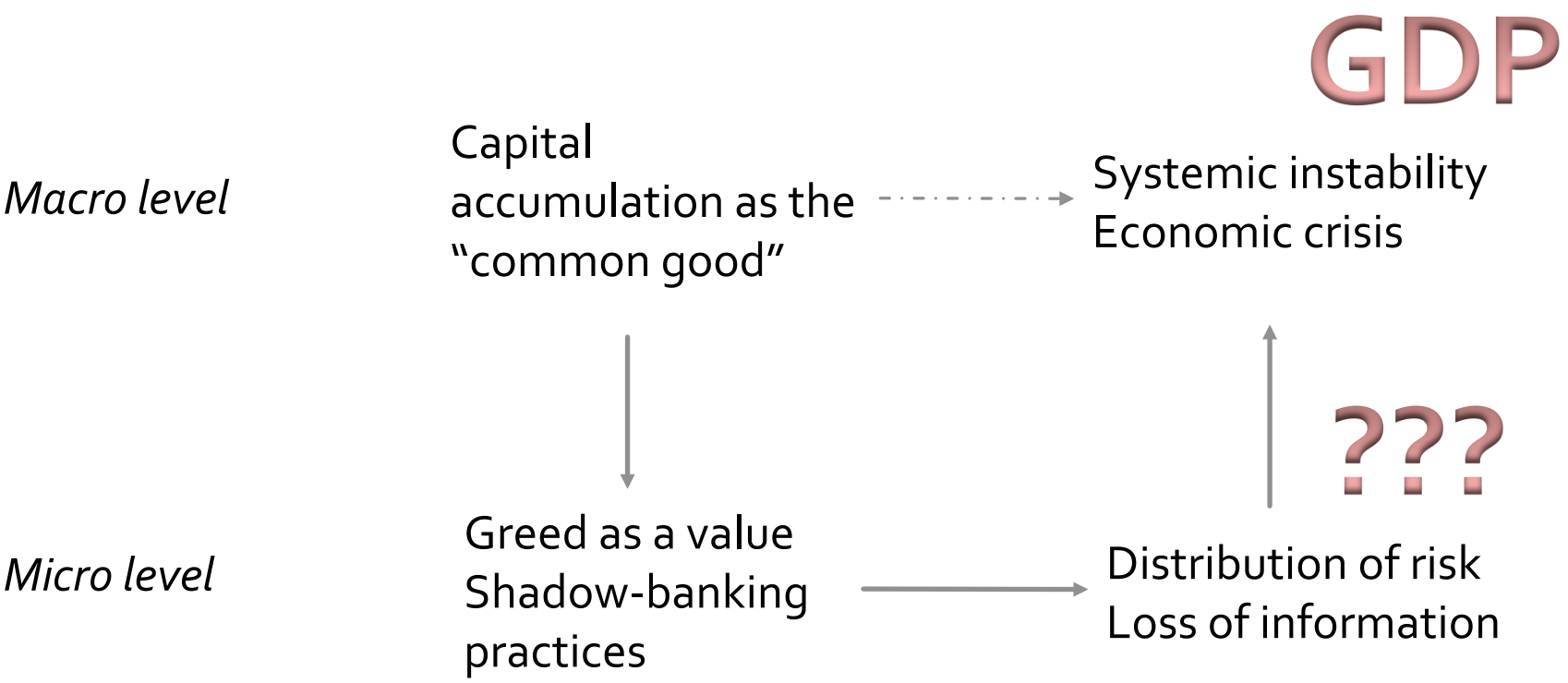
**Upper Red Line:** The maximum elevation level set for the Kinneret is called the upper red line, and it is set at -208.80. When the water rises above this, the Deganya dam must be opened in order to prevent the lake from flooding.

**Lower Red Line:** The lower red line is set at 213 meters below sea level. When the water level drops below this, it can be dangerous to pump water from it. However, due to continous drops in the water level since 1996, the Water Commissioner has lowered this legal limit during certain time periods.

**Black Line:** In 2008, a black line of -214.87 meters below sea level was set. The Water Authority warned that allowing the lake to drop below this level could cause ecosystem instability, deterioration of water quality, damage to nature and landscape assets, receding shorelines, and adverse impacts on tourism and recreation. When the black line is reached, the pumps in the Kinneret cease operating.

Israel Ministry of Environmental Protection

# Lack of information



KNOWLEDGE
Set of narratives, data and models useful
to deal **successfully** with **relevant** issues

This definition of KNOWLEDGE implies the definition of a STORY-TELLER needed to provide a definition of "**success**" and "**relevance**"

IGNORANCE → LACK OF KNOWLEDGE
lacking adequate information (narratives, data and models) that would be required to deal **successfully** with **relevant** issues

*In relation to what?*

*For whom?*

*Uncertainty*

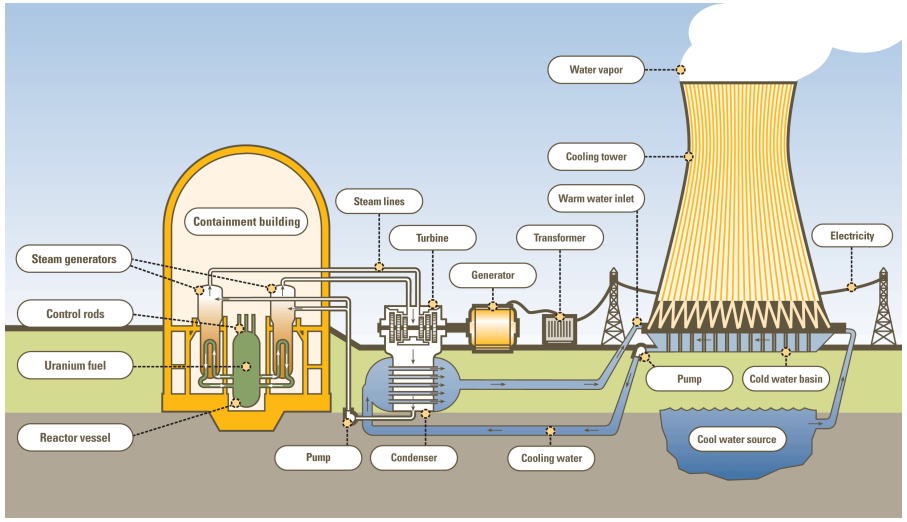
*Hypocognition*

# How can this tool be used?

- Identify problem framings that generate uncertainty
- Asking pertinent questions

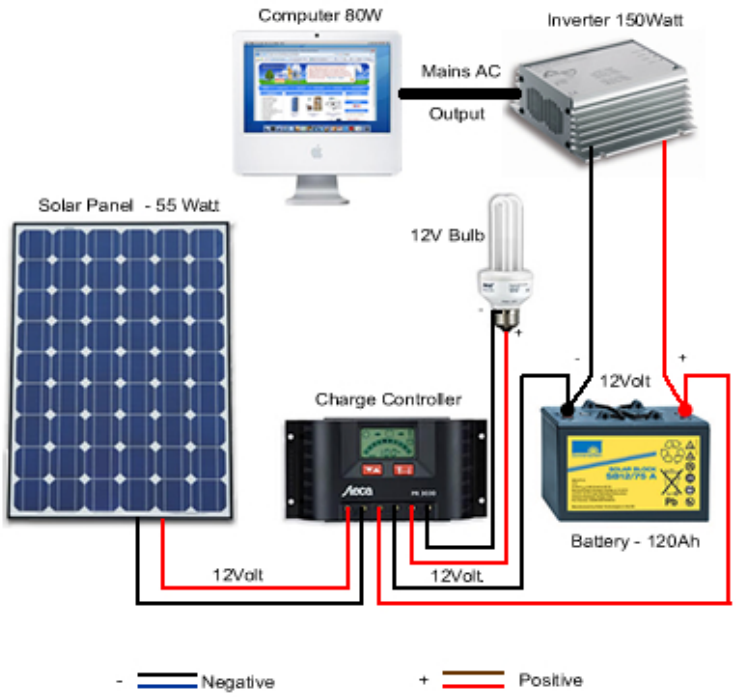
# Dealing with uncertainty

Technical know-how ≠ Large scale application



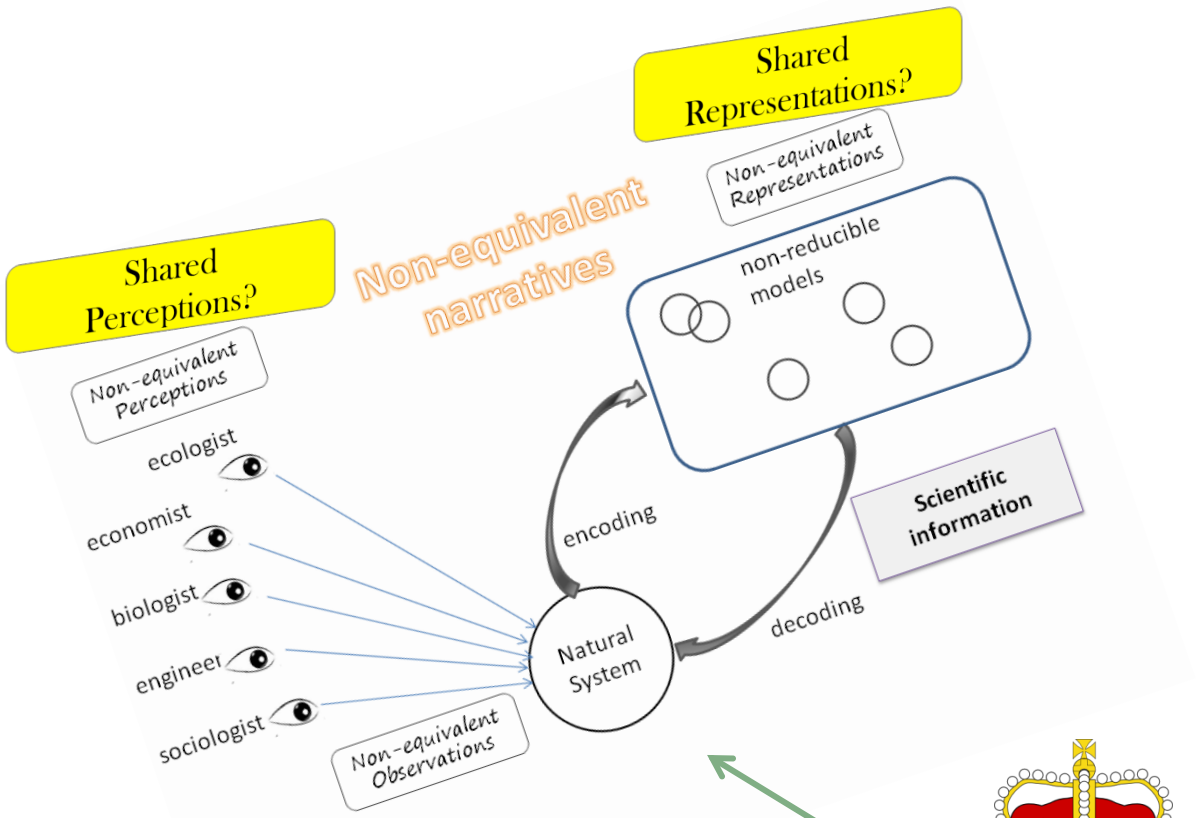

# Dealing with uncertainty

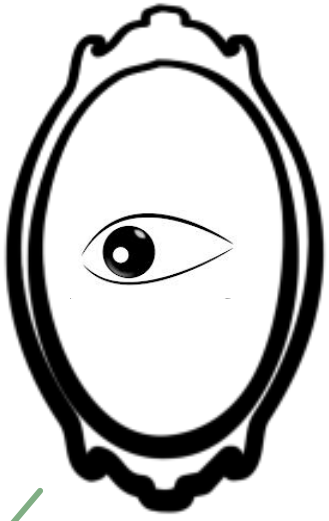
Technical know-how ≠ Large scale application




# Reflexivity

- Who defines the relevant representation of an issue?
- To what extent is it worth producing more accurate measurements?



*Does the scientific information used for decision making refer to socially robust perceptions and representations?*

*Do I have the same values, goals, taboos (= preception of problems) as the rest of society*?*

Story-teller

** which society?*

*Who should choose the relevant narratives and how?*

# How can this tool be used?

- Assess the usefulness of the problem definition and the research question
- Should policy be based on evidence?

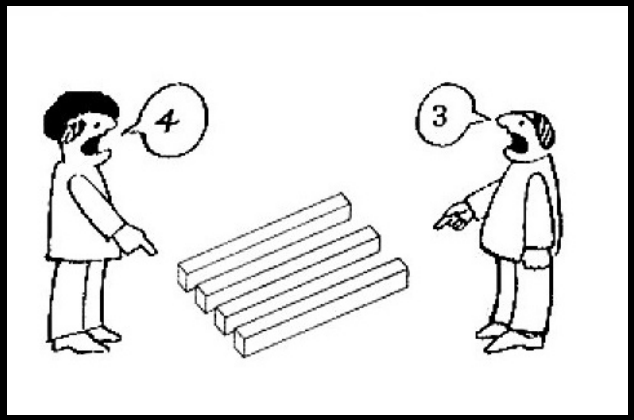
Essentially, all models are wrong, but some are useful.

(George E. P. Box)

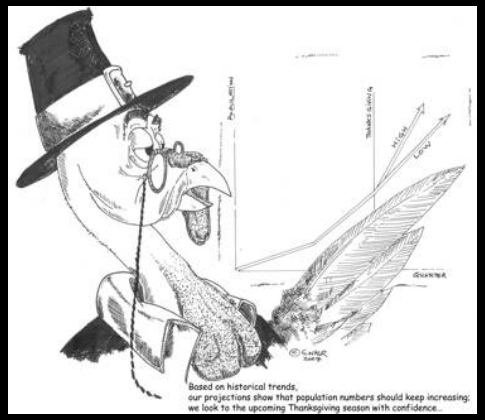
# New narratives

- What makes a model useful?
- Who defines the purpose?

GDP was created during WWII in order to measure the productive capacity of the economy for war – is this model still useful to assess economic performance?








# Thank you for your attention!