Gaps in Ocean-Related Knowledge, Products, and Observations

Hans-Peter Plag
Old Dominion University
Norfolk, VA, USA
Gaps in Sustainability-Related Knowledge, Products, and Observations

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The gaps we see depend on what we want to achieve.

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Improving the present while liberating the future: requires foresight.

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Hans-Peter Plag
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The Baseline: Past Climate and Global Change

(a) CO₂, CH₄ and Sea Level

(b) Climate Forcing

(c) Temperature Change
Long-term (centuries to millennia) correlations:

- $130 \text{ ppm CO}_2 \iff 5^\circ \text{C}$
- $130 \text{ ppm CO}_2 \iff 130 \text{ m in sea level}$
Long-term (centuries to millennia) correlations:

- 130 ppm CO₂ <=> 5°C
- 130 ppm CO₂ <=> 130 m in sea level
The Prognosis: Anticipating Surprises

“Current State”

“Normal Range”
(800,000 years)
The Prognosis: Anticipating Surprises

“Prognosis”

“Current State”

“Normal Range” (800,000 years)
The Prognosis: Anticipating Surprises

Marcott et al., 2013
The Prognosis: Anticipating Surprises

Marcott et al., 2013

IPCC Assessment: Very Likely by 2100

---Post-Holocene

---Holocene---

B

Temperature Anomaly (°C)

Years (BP)

Mann et al. reconstruction
Marcott et al. reconstruction

Extended timeframe
Previous timeframe

Marcott et al., 2013
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Do we understand the scale of changes?
HUMANITY’S JOURNEY
The Evolution of Key Environmental Factors

10,000 BC

AIR TEMPERATURE
0.01°C/century

CO₂
0.2 ppm/century

SEA LEVEL
0.05 m/century

POPULATION
16 M/century

ENERGY CONSUMPTION
0.01 TW/century

GINI COEFFICIENT
0.003/century

1,900 AD

Stability
Humanity's Journey
The Evolution of Key Environmental Factors

<table>
<thead>
<tr>
<th>Factor</th>
<th>10,000 years</th>
<th>100 years</th>
<th>1,900 AD</th>
<th>2,000 AD</th>
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</thead>
<tbody>
<tr>
<td>Air Temperature (°C/century)</td>
<td>0.01</td>
<td>1.0</td>
<td></td>
<td>100x Faster</td>
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<tr>
<td>Carbon Dioxide (ppm/century)</td>
<td>0.2</td>
<td>120</td>
<td></td>
<td>600x Faster</td>
</tr>
<tr>
<td>Sea Level (metres/century)</td>
<td>0.05</td>
<td>0.2</td>
<td>4 x Faster</td>
<td></td>
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<tr>
<td>Population (million/century)</td>
<td>16</td>
<td>5500</td>
<td>350 x Faster</td>
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<tr>
<td>Energy Consumption (Terra Watts/century)</td>
<td>0.01</td>
<td>16</td>
<td>1600 x Faster</td>
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</tr>
<tr>
<td>Gini Coefficient (per century)</td>
<td>0.0003</td>
<td>0.3</td>
<td></td>
<td>100 x Faster</td>
</tr>
</tbody>
</table>

© 2015 Tivah

Stability
Change
Uncertainty
**Humanity’s Journey**

The Evolution of Key Environmental Factors

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10,000 BC: **Stability**

20th and 21st Century: **Change, imbalance**

Future: **Uncertainty**

10.000 BC: Holocene

1,900 AD: 2,000 AD
We are the operators of Earth’s life-support system
We are rapidly reengineering the planet without a clear strategy, a design consideration, a plan.

Rockstrom and Klum, 2015

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We are heading for a planet without other large mammals - only sapiens left.
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“We are the Asteroid”

We are the operators of Earth’s life-support system

Rockstrom and Klum, 2015
We are replacing homeostasis with disequilibrium
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We are replacing homeostasis with disequilibrium

Solar: 89,000 TW
Wind: 370 TW
Additional: ~0.5 TW
Human usage: 18 TW

1900 – 2015
We are replacing homeostasis with disequilibrium.

Solar: 89,000 TW
Wind: 370 TW
Additional: 320 TW
Human usage: 18 TW

Additional heat storage: 93% in the ocean.
We are replacing homeostasis with disequilibrium

Solar 89,000 TW

Wind 370+ TW

Additional 320 TW

Human usage 18 TW

Additional heat storage: 93% in the ocean

It’s not a Greenhouse effect; it’s a Poolhouse effect
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Do we understand the scale of changes?

Do we have useful concepts?
“Sustainable Development is a development that meets the needs of the presence while safeguarding Earth's life-support system, on which the welfare of current and future generations depends.”

Griggs et al., 2013
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*Griggs et al., 2013*

Earth: Our Life-Support System

The Ocean is crucial in the life-support system
Humanity and Earth

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Earth is an “undiagnosed Patient”
A Holistic View

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Earth: Our Life-Support System
The Ocean is crucial in the life-support system
Earth is an “undiagnosed Patient”
Everything is about Flows
Flows have accelerated in the last 100 years
United Nations’ Agenda 2013: “Road to Dignity”

1. NO POVERTY
2. ZERO HUNGER
3. GOOD HEALTH AND WELL-BEING
4. QUALITY EDUCATION
5. GENDER EQUALITY
6. CLEAN WATER AND SANITATION
7. AFFORDABLE AND CLEAN ENERGY
8. DECENT WORK AND ECONOMIC GROWTH
9. INDUSTRY, INNOVATION AND INFRASTRUCTURE
10. REDUCED INEQUALITIES
11. SUSTAINABLE CITIES AND COMMUNITIES
12. RESPONSIBLE CONSUMPTION AND PRODUCTION
13. CLIMATE ACTION
14. LIFE BELOW WATER
15. LIFE ON LAND
16. PEACE, JUSTICE AND STRONG INSTITUTIONS
17. PARTNERSHIPS FOR THE GOALS
United Nations’ Agenda 2013: “Road to Dignity”

Each Goal comes with up to 10 Targets
Each Target comes with up to two indicators
We ask questions like:
What can we do to support SDG implementation and monitoring?
United Nations’ Agenda 2013: “Road to Dignity”

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How can a SDG be successful?
What does a goal need to grow into a successful goal?
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A new Paradigm:
Giving each SDG its own life
Seeing the world through the eyes of a SDG
Realizing, the world is not prepared for the goals
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Implementing SDGs

The Life of a SDG: How to grow into a successful SDG?

Credit: Impact Hub Network/Flickr under Creative Commons license
Implementing SDGs

The Life of a SDG: How to grow into a successful SDG?

What do I need to learn?

Do I understand the challenge?

Who can help me?

What should I do?

Who is going to be impacted?

Credit: Impact Hub Network/Flickr under Creative Commons license

Plag, 2017
Implementing SDGs

The Life of a SDG: How to grow into a successful SDG?

- What do I need to learn?
- Do I understand the challenge?
- Who can help me?
- Am I on the right track?
- Who is going to be impacted?
- What should I do?
- What do I need to learn?

2030

2015

Credit: Impact Hub Network/Flickr under Creative Commons license

Plag, 2017
Implementing SDGs

The Life of a SDG: How to grow into a successful SDG?

- Am I on the right track?
- Who is going to be impacted?
- What should I do?
- Do I understand the challenge?
- Who can help me?
- What do I need to learn?
- How am I going to impact the other guys?
- What do all the other guys need to do so that I can be successful?

Credit: Impact Hub Network/Flickr under Creative Commons License

Plag, 2017
Assessing Interdependencies
Assessing Interdependencies

**SDG14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development**

Stefanie Schmid
Barbara Neumann
Yvonne Waweru
Carole Darussel
Sebastian Unger
Martin Visbeck

[Diagram showing key interactions between SDG14 and other SDGs with scores ranging from -3 to +3.]
Assessing Interdependencies

Oceans and the Sustainable Development Goals: CO-BENEFITS, CLIMATE CHANGE & SOCIAL EQUITY

14 LIFE BELOW WATER
Assessing Interdependencies

Co-benefits of achieving targets for Sustainable Development Goal 14: Life Below Water
The critical issues include:
- overfished/declining fish stocks,
- loss of habitat and biodiversity,
- marine and land-based sources of pollution,
- invasive species, primarily lionfish,
- climate change impacts.
Implementing the Ocean SDG in the Wider Caribbean: state of play and possible ways forward

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- overfished/declining fish stocks,
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- marine and land-based sources of pollution,
- invasive species, primarily lionfish,
- climate change impacts.

Symptoms, not “Issues”/Causes

Fanning and Mahon, 2017
Assessing Interdependencies

4 Interdependencies and interactions of SDGs, Targets and Indicators

○ SDG interdependencies

Jules-Plag and Plag, 2016. Addressing SDG Interconnections and supporting SDG Policy Development with Agent-Based Models: The Example of Gender Equality and Subsistence Farming
Assessing Interdependencies

Implementing & Monitoring the Sustainable Developments Goals in the Caribbean: The Role of the Ocean
January 17-19, 2018
Saint Vincent and the Grenadines

- Ocean exploitation
- Ocean pollution
- Ocean acidification
- Ocean warming

Changes in marine ecosystem
Changes in ocean circulation
Changes in water cycle
Changes in sea level
Assessing Interdependencies

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Humanity is causing
- Ocean exploitation
- Ocean pollution
- Ocean acidification
- Ocean warming

System is responding
- Changes in marine ecosystem
- Changes in ocean circulation
- Changes in water cycle
- Changes in sea level
A Holistic View
A Holistic View

Feeding a growing Population

2. Zero Hunger
A Holistic View

Feeding a growing Population

Accelerating energy flow by accelerating C cycle
A Holistic View

Feeding a growing Population

Accelerating energy flow by accelerating C cycle

Accelerating N and P cycles

Changing land use
A Holistic View

Feeding a growing Population

Accelerating energy flow by accelerating C cycle

Accelerating N and P cycles

Changing land use

Overload of ocean with nutrients

Hypoxic (dead) zones
On their quest to learn more about toxic substances produced by cyanobacteria, Dr. Paul Cox and his team discover a link between cyanobacteria and ALS, Alzheimer's, and Parkinson's.

*Director: Bo Landlin, 2017*
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Sustainability Science

Foreseeability and Foresight:

- What might happen?
- Possible threats and hazards
- Knowing the system trajectory

System Knowledge
Foreseeability and Foresight:

- What might happen?
- Possible threats and hazards
- Knowing the system trajectory
- What do we want to happen?

System Knowledge
- Current state and trends

Goal Knowledge
- Desirable future
Foreseeability and Foresight:
• What might happen?
• Possible threats and hazards
• Knowing the system trajectory
• What do we want to happen?
• How can we impact the system trajectory?

System Knowledge

Goal Knowledge

Transformational Knowledge

System knowledge
Current state and trends

Transformation knowledge
Facilitating pathways

Goal knowledge
desirable future
Foreseeability and Foresight:

- What might happen?
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Do we the knowledge to get to a desired future?

How can science & earth observations support the SDGs?
Gap Analysis

Gaps

- Knowledge
  - Not having the capacity to use
- Discovery
  - Not knowing how to access
- Processing
  - Not knowing what is available

Experts

Observation

Figure 1 Linkage between knowledge needs and observations
Gap Analysis

EVs: Expert-Based Approach
Gap Analysis

EVs: Expert-Based Approach
Gap Analysis

EVs: Expert-Based Approach

Table 1. Synthesis of EVs status

<table>
<thead>
<tr>
<th>GEO Now SBAs (– Climate)</th>
<th>Themes (according to the Hart’s Workshop)</th>
<th>EV name</th>
<th>Domain and/or system component</th>
<th>Status of EV discussion (initial, medium, advanced)</th>
<th>Relevant communities, conventions, others initiatives</th>
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EVs: Expert-Based Approach

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<td>Genetic composition (Co-endemism, Allelic diversity, Population genetic differentiation, Breed and variety diversity)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Species populations (Geographic distribution, Population abundance, Population structure by geographic class)</td>
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</table>

<table>
<thead>
<tr>
<th>Disaster Resilience</th>
<th>Disasters</th>
<th>Initial</th>
<th>Sandcastle Framework</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy and Mineral Resources Management</td>
<td>Energy</td>
<td>Initial</td>
<td>IRENA, IEA</td>
</tr>
<tr>
<td>Ocean (fixed and floating offshore wind, wave, tidal currents, OTEC)</td>
<td>Ocean</td>
<td></td>
<td></td>
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<tr>
<td>Ocean (temperature ocean surface, sub-surface and deep sea)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Ocean (bathymetry)</td>
<td>Ocean (Renewable energy)</td>
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<tr>
<td>Ocean (wave, height, direction, period)</td>
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<td>Ocean (wind speed and direction)</td>
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Jill agrees with Jill about what is essential.
Target 6.3: By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.

EVs: Goal-Based Approach

Target

Indicator

6.3.1 Percentage of wastewater safely treated

6.3.2 Percentage of bodies of water with good ambient water quality

Essential Variable

Water usage
Wastewater treated

Water quality

Governance/policy
Socio-Economic
Infrastructure
Environmental

Jules-Plag and Plag, 2016b
1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance.

1.4.1* Proportion of the population living in households with access to basic services

**Target**

**Indicator**

**Essential Variable**

- Water Supply S.
- Electricity Supply S.
- Sewage S.
- Communication S.
- Public Health S.

**Governance/policy**

**Socio-Economic**

**Infrastructure**

**Environmental**

*Jules Plag and Plag, 2016b*
SDGs-Related Gaps

- SDG-GP-0: There is a lack of an epistemology for the creation of transition knowledge from the current system state and trajectory to the desired future.
- SDG-GP-1: No integrated environmental and socio-economic databases
- SDG-GP-2: Insufficient accounting for environmental variables in SDG indicators
- SDG-GP-3: Missing link between SDGs and sustainability
- SDG-GP-4: Missing tools and capacity to assess cross-SDG dependencies
- SDG-GP-5: Missing tools for assessing cross SDG impacts and policies
- SDG-GP-6: Skills required for matching providers and policy makers
- SDG-GP-7: Many of the ESDGSVs for the built environment are not measured
Gap Analysis

Prioritization

![Graph showing a 3D matrix with Impact, Costs, and Feasibility axes, with labeled targets for 1st and 2nd priorities.](image)
SDGs-Related Gaps

Polyglot Data

Graphs:
- "social" networks among SDGs, Targets, Indicators, data, models, people
- Networking for SDGs: "SDbook", "SDlinked"
- Communication for SDGs: "SDChitter", "SDTube", "SDBox", "SDFlash", ...
- Functional network analyses
- Gap analyses
- Deep learning

Toward a Better World for the SDGs
A series of dialogue-scenarios, which can be read as poems or plays, describing the "knots" and impasses in various kinds of human relationships.
We have a complex/wicked problem
We have a complex/wicked problem

Governance/Science/Private

Earth Observation

Match Making
We have a complex/wicked problem

We will help you find partners!
We have a complex/wicked problem

We will help you find partners!

We need networks A, B, and C

Match Making