Aligning the Digital Transformation with the UN Sustainable Development Goals

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Growing Political Interest in Aligning Digitalization with Sustainability

- World Economic Forum, 2018/19
- German Advisory Council on Global Change, 2020
Questions

1
What is Sustainable Development (SD) and why is it difficult to achieve?

2
What role has digital transformation played so far in achieving the UN Sustainable Development Goals (SDGs)?

3
Are we missing an opportunity by underestimating the potential of digital technologies for SD?
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The report that coined the term “sustainable development”

The UN report “Our Common Future” introduced the term with the following definition (also known as the “Brundtland definition”):

“Sustainable development is development which meets the needs of the present without compromising the ability of future generations to meet their own needs.”

World Commission on Environment and Development (UN-WCED), 1987
The UN Agenda 2030 and the Sustainable Development Goals

In 2015, all 293 United Nations Member States adopted the 2030 Agenda for Sustainable Development.

It contains the 17 Sustainable Development Goals (SDGs), which are intended to “stimulate action over the next fifteen years in areas of critical importance for humanity and the planet”, namely the “five P”:

– People
– Planet
– Prosperity
– Peace
– Partnership
The SDGs address different levels of the overall human-environment system

17 Partnerships for the goals

**Economy:**
8 Decent work, economic growth
9 Industry, innovation, infrastructure
10 Reduced inequalities
12 Responsible production & consumption

**Society:**
1 No poverty
11 Sustainable cities & communities
16 Peace, justice, strong institutions
7 Affordable & clean energy
3 Good health and well-being
4 Quality education
5 Gender equality
2 Zero hunger

**Biosphere:**
15 Life on land
14 Life below water
6 Clean water & sanitation
13 Climate action

Credit: Azote Images for Stockholm Resilience Centre
The system levels are connected through social metabolism

The socio-economic system acts like an organism that
- absorbs substances from the environment,
- transforms them, and
- releases them back to the environment

**Inputs:**
- minerals and ores, fossil fuels
- biomass
- water

**Outputs:**
- emissions into air
- solid and liquid wastes into soil and water

Input rate still growing: global material extraction at 90 billion tonnes/year

http://www.materialflows.net/visualisation-centre/
“Despite rapid technological changes, digitalisation in particular, the data from the last decades shows that most rates of socio-economic change are slow. [...] this pace of progress proves insufficient to deliver on the SDG targets by 2030 nor 2050.” (p. 13)
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Strategies for achieving sustainable development

<table>
<thead>
<tr>
<th>Efficiency</th>
<th>More units of useful output per unit of input (e.g., energy, material, time, money)</th>
<th>Necessary to enable growth under resource constraints.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sufficiency</td>
<td>“Seeking enough when more is possible” (Princen, 2005)</td>
<td>Necessary to avoid rebound effects that compensate for efficiency.</td>
</tr>
<tr>
<td>Consistency</td>
<td>To make social metabolism consistent with nature’s metabolism</td>
<td>Necessary to enable long-term compatibility of social and natural metabolism.</td>
</tr>
</tbody>
</table>

“The transformation of traditional industrial structures […] implies major or basic technological innovations, as being different from incremental efficiency increasing change.” (Huber, 2000, p. 269)


Thomas Princen. The Logic of Sufficiency. MIT Press, 2005
Energy efficiency of computing (Koomey’s Law)

The number of computations produced per energy input has doubled every 1.57 years since the time of tENIAC, the first programmable electronic computer.

Material efficiency of computing

Computing power per kg microchips increased by a factor of 100 million

Lorenz Hilty, European Computer Science Summit 2021, Madrid
Example: Planned 5G network infrastructure for 2030 in Switzerland

- Greenhouse gas efficiency in GB transferred per kg CO$_2$e emitted will **increase by a factor of 6.7** to 222 GB/kg (or 4.5g/GB)

- Capacity is planned under the assumption that data traffic will **increase by a factor of 9.3**

It follows that the CO$_2$ emissions of the mobile network will **increase by 39%**.

Materials Complexity of ICT Hardware

Chemical elements used today to build digital electronic devices

Base metals, e.g.:
- Aluminum (Al)
- Iron (Fe)
- Copper (Cu)

Scarce metals, e.g.:
- Gold (Au)
- Silver (Ag)
- Palladium (Pd)
- Indium (In) ...

Critical metals, e.g.:
- Gallium (Ga)
- Germanium (Ge)
- Indium (In)
- Tantalum (Ta)
- all Rare Earth Elements (Sc, Y, La, Ce–Lu)

The red line indicates the elements that are in use for building microprocessors and related electronic components today.

An element is called “critical” if there are high supply risks (for geological, technical, environmental, social, political or economic reasons) and the prospective impact of supply restrictions is high.

Lorenz Hilty, European Computer Science Summit 2021, Madrid
Metallurgical recovery of metals from e-waste

- Example: Umicore (Belgium) invested more than 100 million Euro in the development and installation of the metallurgical process shown here.

- Recovering precious metals such as Gold (Au), Silver (Ag), Platinum (Pt) is more efficient than mining these metals from the earth crust.

- Not all critical metals are recovered due to trade-offs: The process can only target a subset of all elements.

Source: Umicore
Informal e-waste recycling in Delhi, India

Source: Empa
Copper extraction in the backyard

Manual extraction of copper from printed wiring boards in Delhi, India. Typical backyard company with 12 workers. Yield: 1-2 tons/month

Source: Empa
From “Our Common Future” to “Our Common Digital Future”

## Opportunities and risks of digitalization (1/4): economy level

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<tr>
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<th>Opportunities of digitalization</th>
<th>Risks of digitalization</th>
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<tbody>
<tr>
<td>8</td>
<td>Decent work, economic growth</td>
<td>New forms of <strong>market access</strong>, employment opportunities</td>
<td>Societal challenges posed by automation and new forms of work</td>
</tr>
<tr>
<td>9</td>
<td>Industry, innovation, infrastructure</td>
<td>Innovation promotion and transfer, e.g. to <strong>leapfrog</strong> technological development stages, or for smart city infrastructures</td>
<td>Lack of the corresponding frameworks or other (e.g. development politics) problems which frequently hinder sustainable implementation</td>
</tr>
<tr>
<td>10</td>
<td>Reduced inequalities</td>
<td>Reduce inequalities through enabling technological leaps, new forms of employment and <strong>access</strong> to information, education and health</td>
<td>Promote inequalities through the reshoring of production, automation or a widening digital <strong>divide</strong></td>
</tr>
<tr>
<td>12</td>
<td>Responsible production &amp; consumption</td>
<td>Decoupling of economic development from resource and energy consumption, as well as a digitally enhanced change towards ‘<strong>using instead of owning</strong>’</td>
<td><strong>Increased demand</strong> for resources and energy, short product cycles and increasing quantities of electronic waste</td>
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<td>1</td>
<td>No poverty</td>
<td>Support the integration of the poorest into the (world) economy and partly compensate for a lack of institutional frameworks</td>
<td>New dependencies and divides</td>
</tr>
<tr>
<td>7</td>
<td>Affordable &amp; clean energy</td>
<td>Integrate renewable energies into electricity grids; support the electrification of other sectors; support access to stable electricity in remote regions (e.g. mini- and off-grids).</td>
<td>Growing energy demand in the ICT sector</td>
</tr>
<tr>
<td>11</td>
<td>Sustainable cities &amp; communities</td>
<td>Improve utility services, mobility and administration in cities</td>
<td>Failing to meet the needs of large sections of the population; smart-city approaches are often not holistically oriented towards sustainability and the broad common good</td>
</tr>
<tr>
<td>16</td>
<td>Peace, justice, strong institutions</td>
<td>States make use of digitalization for better governance (eGovernment)</td>
<td>State surveillance and control (social scoring); lack of ICT access hampers the potential for civic participation and citizen's services; cyber threats to infrastructures, peace, international law</td>
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<td>2</td>
<td>Zero hunger</td>
<td><strong>Precision agriculture</strong> can reduce environmental damage and promote diversity; access to (digital) information and advice as well as open-source and sharing concepts can help small farmers in developing countries to increase yields.</td>
<td>New <strong>dependencies</strong> on agricultural corporations.</td>
</tr>
<tr>
<td>3</td>
<td>Good health and well-being</td>
<td>eHealth; environmental sensor technology (e.g. protection against pollutants); <strong>medical 3D printing</strong> (e.g. prostheses); health apps</td>
<td>Access barriers, data misuse, loss of quality and new hazards (e.g. addiction, radiation, accident risks)</td>
</tr>
<tr>
<td>4</td>
<td>Quality education</td>
<td>Educational content can be made broader-based, more inclusive and more easily <strong>accessible</strong>.</td>
<td><strong>Inequalities in access</strong> and digital literacy, between developing and industrialized countries and between the genders</td>
</tr>
<tr>
<td>5</td>
<td>Gender equality</td>
<td>Emancipatory potential in the measurability and visualization of existing inequality; new opportunities for <strong>access</strong> and inclusion</td>
<td>Reproducing <strong>access barriers</strong>, discrimination and stereotypes.</td>
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Lorenz Hilty, European Computer Science Summit 2021, Madrid
## Opportunities and risks of digitalization (4/4): biosphere level

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<td>6</td>
<td>Clean water &amp; sanitation</td>
<td><strong>Efficiency and effectiveness of water-supply systems and waste-water treatment</strong>; digitally enhanced irrigation and water management</td>
<td>System vulnerability and investment costs creating new <strong>dependencies</strong></td>
</tr>
<tr>
<td>13</td>
<td>Climate action</td>
<td>Potential for climate-change mitigation and adaptation to climate change; <strong>early-warning systems</strong> and disaster preparedness</td>
<td><strong>Driving energy-related</strong> CO2 emissions</td>
</tr>
<tr>
<td>14</td>
<td>Life below water</td>
<td>Help fight overfishing; digitally enhanced <strong>circular economy</strong> can reduce marine waste in the long term</td>
<td>Driving a type of economic development that results in <strong>overburdening</strong> of the oceans’ production and sink function</td>
</tr>
<tr>
<td>15</td>
<td>Life on land</td>
<td>Sustainable <strong>precision agriculture</strong> (see SDG 2); monitoring for the conservation of ecosystems and biodiversity; new opportunities for nature conservation</td>
<td>See SDG 2</td>
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The challenge of consistency in agriculture

Non-selective herbicides are sprayed to 100% of the plants on the field, although <10% would be sufficient if the application to weed would be selective.

The dramatic effects on biodiversity and human health show the extend if inconsistency.
Weed robots can save up to 90% herbicides

Project MARS, 2017

Eurobotics, 2020
Reducing the burden of inconsistent flows by circular economy

- Design for longevity
- Design for service (i.e. shareability)
- Design for re-use in manufacture
- Design for material recovery
- ...

→ Many opportunities for digital technologies to play an enabling role.

Source: Aktionsprogramm für Nachhaltigkeit, Abfall und Ressourcen, innovatives Denken
Circular economy with recycling robots

Construction and demolition waste (Zenroboticx)

Zenroboticx (2016)  
https://youtu.be/uaft5MR7GAc?t=71

Alphabet X 2019
The future: robot rats?

“Robot rats are the future of recycling

[…] Why don’t we have swarms of robots in our landfill yet, when most of the technological problems seem to be solvable? […] It’s clear robotic technology can develop pretty fast when given the right resources. […] The engineers work according to our priorities, so if we want to see progress, we need to put our money where rubbish is.”

Sunny Bains: Robot rats are the future of recycling. OUPblog, Oxford University Press’s Academic Insights for the Thinking World. August 8, 2019
Conclusion: Four Principles of sustainable digitalization

Promote efficiency with regard to energy or material resource input only when there is some constraint that hinders demand to grow faster than efficiency. (Combine efficiency with sufficiency.)

Use the ability of digital technologies to make efficient automated distinctions to reduce the inconsistency of social metabolism, not to induce more consumption. (Use efficiency for consistency.)

Promote accessibility of information, markets and sharable resources only if this increases equality and reduces divides, and can be scaled up to large numbers of people in a world of finite material and energy resources. (Use the technology to reduce inequality.)

Avoid creating dependency and addiction of consuming specific services provided by digital technologies. (Preserve freedom of choice.)