Wuppertal Institut

in brief 08 | 2019

Sustainability Impulses from Wuppertal

Steering Digitalisation in the Right Direction – Key Points for Science and Politics

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Background

Digitalisation is in full swing and it is changing and influencing the world of the 21st century as no other dynamics of change has done before. Dealing with its impacts and at the same time shaping digitalisation itself is therefore a core task for achieving a globally sustainable transformation (German Advisory Council on Global Change (WGBU) 2019). But which direction should digitalisation take to ensure that it makes effective contributions to globally sustainable development? And what is the specific approach needed to steer digitalisation in the right direction?

1. Digital transformation and sustainability – what needs to be done now

Digital technologies can support sustainable development and open up new potential in many areas for reducing greenhouse gas emissions and resource consumption. Collecting and evaluating product and usage data, for example, is the basis for innovative business models aimed at re-use, re-manufacturing and recycling in the circular economy (Wilts & Berg 2017).

Moreover, in the interplay between an increasingly connected daily life featuring fundamental new qualities of learning, autonomous systems, artificial intelligence (AI), and the spread of digital platforms, previously unknown transformation dynamics are building up. The growth-driven economic model of industrial societies is being given an additional boost, at the same time the constraints and rules of economies are changing under digital platform capitalism.

In this context, the ecological drawbacks of digitalisation are becoming increasingly evident due to the rising environmental impact of information and communication technologies. The contradictions are intensifying between often exponential digital growth dynamics and the urgent need to comply with the global limits on environmental impact and resource consumption. With the digital data flows, differentiated access to data and a new type of discourse, the fundamentals of coexistence in democratic societies are also changing dramatically.

In the meantime, increasing numbers of scientific works and publications are addressing the ambivalence of the socio-ecological opportunities and risks of digitalisation.[1] The awareness of the problem is growing and now needs to be transferred into concrete action. It is primarily a case of shaping the current **digital transformation in the context of sustainable development for society and politics.**[2] To this end, fields of action must be defined and made tangible in terms of their specific impact parameters, causalities and consequences.

2. Sustainability requires more than digital technologies – focusing on digital solutions as socio-technical innovations

With the Digital Transformation Research Unit, the Wuppertal Institute is taking a stronger stand in the debate focusing on the interactions between sustainable digitalisation and industrial transformation. The starting point is a wider understanding of digital solutions for the transformation towards sustainability as socio-technical innovations.
The following **five aspects** are relevant in this context.

- **1. Digitalisation** is characterised by an **extremely high level of innovation dynamics**. Technical advance is rapidly changing the way data are collected, networked, shared, analysed and used for decision making and interventions in the real world. A number of key technologies such as artificial intelligence (see box) are becoming particularly important in this respect since they are drivers of innovation that are especially critical to achieving rapid success and accelerating innovation.

- **2. Digitalisation** is not a firework display of individual technologies, since the real impact is created through **combining a range of key technologies in digital solutions**. These in turn interact with their environment and their infrastructure. Pioneers and technology leaders are characterised by the ability to constantly expand their **scope of technological activity**, i.e. to re-combine their ecosystem of digital solutions on a constant basis, to expand infrastructures and to cover increasingly large parts of the value chain.

New knowledge-based solutions sought – applying artificial intelligence to the relevant sustainability challenges

The change of perspective from technologies to solutions also has direct consequences for the evaluation of artificial intelligence (AI) as a new key technology in the digital world. Technology is not a goal in itself and it is not just a case of optimising individual applications such as the intelligent control of heating systems. Above all, AI will be able to yield its benefits if it is applied to the relevant challenges associated with the sustainable transformation of organisations, economic systems and infrastructures. A new cooperative problem-solving intelligence is therefore primarily needed in conjunction with a comprehensive understanding of complex problem structures. That means, the ability to achieve a new quality of solution strategies by using AI in a targeted manner as a tool to identify and address interdependencies as well as modes of action in transformation processes, which have previously been insufficiently understood. If used in a smart way, AI can and will make crucial contributions – almost taking on the role of a new **"8th sense"** in the world of data – to manage the ever-growing floods of data, the hidden links and the exploding diversity of options for action, which are beyond the capabilities of perception and processing of human beings.

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[1] Cf. Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen (WBGU), 2019; Rat für nachhaltige Entwicklung, 2018; Sühlmann-Faul & Rammler, 2018; Höfner & Frick, 2019

[2] Cf. Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), 2019

- **3. Digital solutions change information processes, new information processes change the world.** However, new information processes only work to their full extent if they are integrated into or rather implemented in organisational procedures, operating processes, human behaviour and business models. To assess the opportunities and risks of digitalisation for sustainable transformation and the achievement of global sustainability goals, greater attention must be paid to data flows, information processes and their impact on the interplay of people and institutions and their interaction with the environment.

- **4. Digital solutions are therefore essentially socio-technical innovations** and the non-technical aspects of transformation are complex and influenced by diverse social, cultural and organisational factors. However it is precisely these communicative, procedural and organisational adjustments in the **socio-economic sphere** that ultimately change the economy, society and politics, thereby turning digitalisation into such a profound formative power.[3]

- **5.** Above all, **digitalisation can achieve its full ecological potential** where it fundamentally changes current lifestyles and cultures of consumption, business patterns and production methods or the organisation of energy systems, cities and transport. Accordingly, socio-eco nomic driving forces and impact conditions of **digital solutions that fundamentally change the system** must be put at the heart of the digital transformation – as an interplay of different technologies in the context of individual, social, organisational, institutionally regulatory and commercial innovations.

Digital solutions are socio-technological innovations

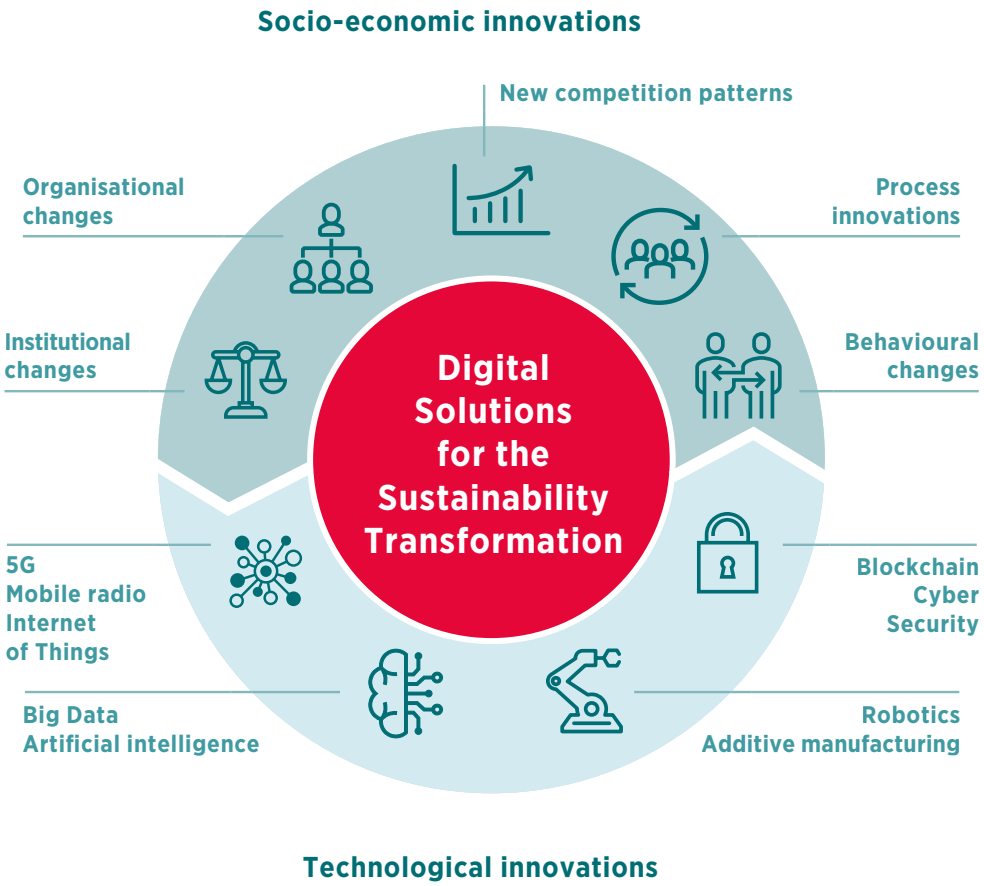

Fig. 2: Digital solutions are socio-technical innovations

[3] The WBGU therefore sees digitalisation as "… no less than a revolution for civilisation" (WBGU 2019)

Shaping the socio-economic framework combined with new technological opportunities and relevant applications for ecology and society is therefore key to sustainable digitalisation. This is where the work of the **Digital Transformation Research** Unit comes in by focusing on **two main areas**:

- Using digitalisation to shape the framework and scope for sustainable industrial transformation
- Ensuring that the conditions for development and application of digitalisation are environmentally friendly by using an eco-political framework

3. An upgrade for Industry 4.0 – transforming the digital factory into a digital circular economy

The industrial transformation aimed at greater resource efficiency and decarbonisation is one of the major tasks of the transformation towards sustainability. Currently, however, the digitalisation of plants and processes as part of the fourth industrial revolution (Industry 4.0) is focused on securing the competitiveness of German industry in the 21st century. What is lacking is a holistic approach towards integrating individual companies into the overall system as well as a resource-efficient circular economy as a shared responsibility, which is why **Industry 4.0 has turned a blind eye to the circular economy until now.**[4]

The next step, therefore, is to **further develop Industry 4.0 into a digital circular economy** in which both the material and information flows are closed and participants are linked together throughout the different stages of the value chain. As a result, the data hub of Industry 4.0 will expand and make information that is currently missing available, for example, on shared platforms for new stakeholders in remanufacturing or recycling (Berg & Wilts 2019). The feedback on the actual use and usability of products and materials can also be considered as information input for research and development as well as engineering and product design at the very beginning of the lifecycle.

4. Making the ecological footprint of digitalisation a key environmental issue

Digitalisation offers **a great number of opportunities for reducing energy consumption and environmental impact as well as greenhouse gas emissions**, and these opportunities must be exploited consistently. **Digitalisation also has an ecological price, however.** The vast numbers of appliances, data centres and communication infrastructures consume increasing amounts of energy and materials and contribute to climate change. In many applications, a rebound effect can be seen, i.e. the targeted savings are partially or entirely offset by increased consumption in other areas. The scientific and empirical basis regarding this question is becoming increasingly wide, but there is still no comprehensive and robust methodology or database for the systematic evaluation and consideration of rebound effects in energy and resource efficiency through digitalisation.

The "physical twin" of the data world leaves an enormous footprint. The challenge is to design devices and infrastructures in a way that is more efficient in terms of resources and energy, to rapidly ensure the supply of carbon-free electricity from renewable energy sources and to plan the sites of data centres, in particular, with a view to optimising waste heat utilisation.

[4] Recently there have been initial signs of an expansion of the philosophy of Industry 4.0 to include the holistic closed-loop circulation of resources and value, cf. das Leitbild 2030 der Plattform Industrie 4.0 (the Mission statement 2030 for the Industry 4.0 platform) (Federal Ministry for Economic Affairs and Energy (BMWi), 2019). The topic is dealt with much more comprehensively by e.g. the VDMA (German engineering association) as an explicit Zukunftsbild 2030 für den Maschinen- und Anlagenbau (Maiser et al., 2019).

However, the **production** of digital equipment and infrastructures and the **preceding process stages, which cause the lion's share of the associated environmental impact and resource consumption**, are even more relevant than the operation of the equipment. Driven by strong innovation dynamics and corresponding short life cycles in conjunction with constant market growth, the use of critical raw materials in electronic devices is increasing on a global scale. Effective strategies for extracting, processing and recycling the resources used in a way that is environmentally and socially compatible do not exist, yet.

5. Conclusion: an environmental strategy for digitalisation is overdue

Just like electricity at the start of the 20th century, digitalisation is a revolutionary driving force at the start of the 21st century and fundamentally changes the conditions for the development of the economy and the society. Similar to the electricity industry, the digital economy has meanwhile become a sector with its own products, infrastructures, branches of economic activity and considerable environmental relevance, which becomes increasingly evident. In line with the other sectors with environmental relevance such as the energy, chemical or automotive industries, **the digital industry** must therefore **also be addressed by specifically targetal environmental strategies and instruments for decarbonisation and resource efficiency.**

The digital transformation can be steered in the right direction, and the socio-cultural, organisational and institutional environment of digital innovations can be shaped – both as a prerequisite for making the contributions towards sustainability successful and also as a guard against unwanted ecological consequences. The task now is to enable policymakers and society to take action in this context.

The initial key points of the political and research agenda can be summarised as follows:

- **To understand and evaluate the complexity of the impact** by analysing the socio-technical driving forces and interactions and by quantifying the positive and negative environmental impacts of digitalisation including side effects, rebound effects, etc.
- **To measure and quantify the environmental impact** and thereby create and constantly expand a consistent empirical database on energy/material input and resource consumption for the preliminary services, the production and the operation of digital devices, applications and infrastructures.
- **To define indicators and targets** for controlling the resource consumption and climate change impacts of digitalisation in all areas of application, and for systematically monitoring these, e.g. in the context of the EU Ecodesign Directive or in the form of new energy efficiency labels.
- **To set incentives and frameworks,** to mobilise the economic potential for climate-friendly and resource efficient digital solutions – new digitally supported business models and sustainable lifestyles must be profitable and require the freedom to flourish.
- **To develop political instruments and strategies for flexible targets.** This requires new concepts and methods for innovative political action and experimental social learning in a highly dynamic environment, which reacts more rapidly than traditional political processes could react.

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