Martin Held

SPATIAL TRANSFORMATION – AN INTRODUCTION TO THE GREAT TRANSFORMATION TOWARDS SUSTAINABILITY

Contents

1 Introduction
2 Transformation – transitions – the Great Transformation towards sustainability
2.1 Multi-level perspective and sustainability transition management
2.2 Ecological and socio-ecological sustainability transformation
2.3 The Great Transformation towards sustainability
3 Space-specific transformation research – time-conscious
3.1 Spatial transformation – space, place, scale
3.2 Times – spaces
4 The Great Transformation towards sustainability – conceptualisation
4.1 Transformation – form of time transition and space-time scales
4.2 Phasing-in and phasing-out
4.3 Interactions between multifaceted processes
5 Themes and differentiations
5.1 Power, interests, actors, conflicts, justice
5.2 Planning and controllability of transformation processes
5.3 Energy transition, mobility transformation, raw material transformation – building blocks of the Great Transformation
6 Digital transformation and the Great Transformation towards sustainability
7 Perspective – re-embedding the economy
References

Abstract
A Great Transformation from fossil-based unsustainability to post-fossil sustainable development is on the horizon. This article provides an introduction to the research and debate on the sustainability transformation, with a special focus on the spatial dimension. Examples of current approaches and research are presented. Spatially orientated transformation research requires a view of the temporal processes.[1]

1 The article is based on a working paper by the ARL Working Group on 'Sustainable spatial development for the Great Transformation' (Bauriedl/Held/Kropp 2017). I would like to thank Sybille Bauriedl and Cordula Kropp, as well as Richard Sturn, Barbara Adam, Jörg Schindler and members of the discussion group 'Transformers – actors in the Great Transformation', as well as an anonymous reviewer for their suggestions. Of course, I myself take responsibility for any imprecise formulations and errors that may occur.

Keywords
Great transformation – unsustainability – sustainable development – spatial transformation – transformation approaches – timescapes – landscapes – digital transformation

1 Introduction

> *'What we are currently simultaneously experiencing* [...] *are the* ***very beginnings of the next great transformation:*** *a developed market society must be further developed in a way that permanently guarantees the ecological and social prerequisites for economic activity'* (*Biervert/Held 1994: 25; emphasis in the original*).

The adoption of Agenda 21 at the Rio Conference in 1992 was a great success. The idea of sustainable development found broad acceptance. However, the concept of a fundamental transformation towards sustainability was not yet established. Instead, transformation research in the 1990s related to the transformation countries of the former Soviet Union and its sphere of influence. By way of comparison, transformations of political systems such as the transition from the Franco dictatorship to democracy in Spain (*transición*) were incorporated into this line of transformation research (Merkel 2010).

At the end of the 1990s and beginning of the 2000s, research on transitions towards sustainability developed (early publications include National Research Council 2000). This research encompasses various disciplines and perspectives, with different objectives and research questions. The scope of studies ranges from individual socio-technical innovations and their dissemination to the Great Transformation from unsustainable development to sustainable development. In my article, I introduce this field of research, with a focus on the spatial perspective. Although this field of research s still in its infancy, I can only address a few selected approaches, categories, themes and examples.

2 Transformation – transitions – the Great Transformation towards sustainability

In the context of sustainability, the terms *transformation*(*s*) and *transition*(*s*) are used. Some approaches partially differentiate between transformation and transition (Stirling 2014). The plural form, transitions/transformations, typically describes transformation processes on a smaller scale.

The point of departure is the *unsustainability* of the prevailing economic and social system in industrialised countries. Despite all their differences (*varieties of capitalism*, Hall/Soskice 2001), all capitalist countries have fossil-based unsustainability in common – a development model that is being propagated worldwide. This can be

described as a catch-up development of unsustainability (Schindler/Held/Würdemann 2009: 136 et seq.).

2.1 Multi-level perspective and sustainability transition management

The multi-level perspective (MLP) approach, which was initiated in the Netherlands, has a significant influence on the debates in the research. This approach offers what has hitherto seen the most highly developed structuring of research on sustainability transitions (for an introduction, see Kemp/Schot/Hoogma 1998; Elzen/Geels/Green 2004; Grin/Rotmans/Schot 2010).

The approach has its roots in innovation research. It is not envisaged for purely technological innovations; rather, it considers these to be socio-technological innovations. It has various roots, such as Science Technology Studies (STS), Actor-Network Theory (ANT) and evolutionary economics. The approach is geared towards transitions towards sustainable development. The basic understanding envisages the shaping (management) of specific transitions in the sense of socio-technological innovations. Three levels are distinguished here (Geels/Schot 2010: 25):

(1) *Niche innovations*: technological innovations towards sustainability (networks of actors who support innovations, etc.)

(2) *The socio-technological regime*: the dominant regime (markets and preferences of users, industry, science, culture, politics, technology)

(3) *The socio-technological landscape* (exogenous context): institutions, developments which exert pressure to change, etc.

Landscape is not used in the common sense usually found in the spatial sciences:

> *'The metaphor landscape has been selected because of the literal connotation of relative hardness and to include the various material aspects of society, e.g. material and spatial arrangements of cities, factories and electricity infrastructures'* (Geels/Schot 2010: 23).

The three levels are arranged in a sort of hierarchy: level (1) is embedded in level (2), and level (2) is embedded in level (3). The socio-technological regimes are comparatively more stable than the first level, while the overarching landscape is more persistent, despite all the social changes. At the same time, change pressure on the prevailing socio-technological regime can also be exerted from this level. The diverse interactions, both within each level and between the levels, are emphasised (cf. Fig. 1).

This approach is frequently used as a reference, particularly in studies relating to the spatial dimension; it has been critically discussed and refined by the proponents of the approach. At the same time, the perspective is also used for larger-scale change processes which go beyond individual socio-technological innovations (see section 4.2).

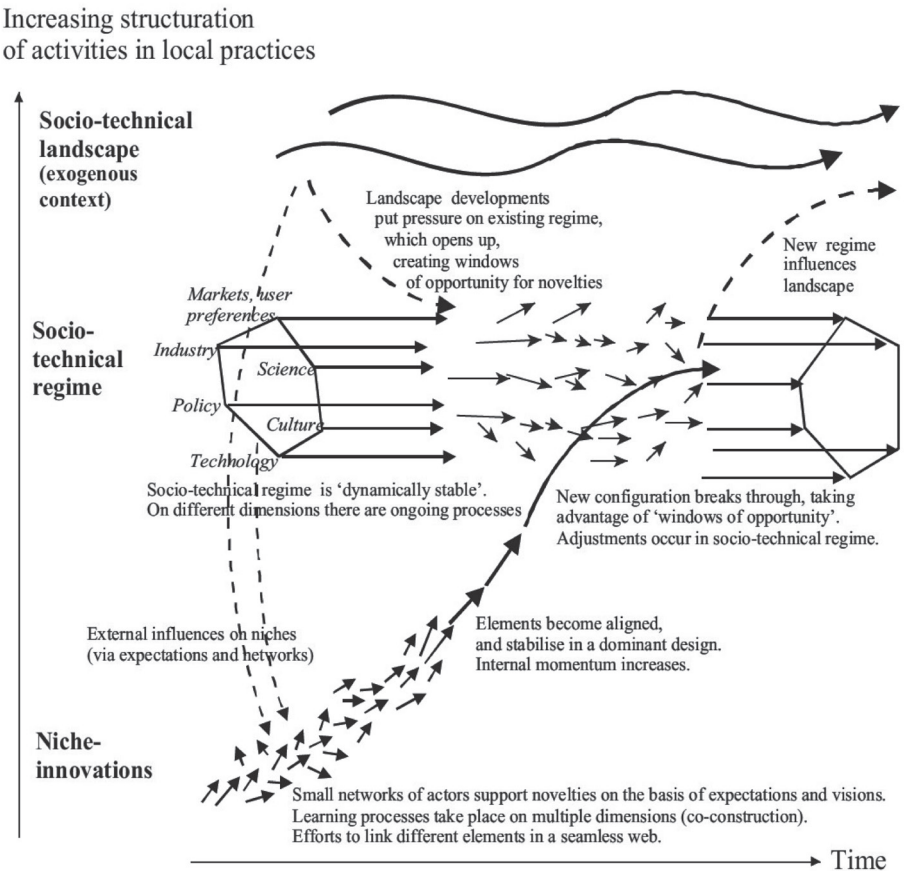

Fig. 1: Multi-level perspective (MLP) on transitions / Source: Geels 2011: 28

2.2 Ecological and socio-ecological transformation

Another root of transformation research focuses on global environmental changes. The necessity of a fundamental transformation towards sustainability is grounded using the synthesising concept of planetary boundaries (for an introduction, see Rockström/Steffen/Noone et al. 2009a, 2009b). The boundaries are assessed as having been exceeded when a loss of biodiversity and a change to the global nitrogen cycle occur. In the case of anthropogenic climate change, the boundaries have not yet been exceeded, but in view of the rate of change, the development is regarded as being extremely critical (IPCC [Intergovernmental Panel on Climate Change] 2018).

In contrast to the MLP approach, this part of transformation research is based not on socio-technological innovations but on the analysis of global ecological change processes. Given the extent of the problems, these require a fundamental transformation from fossil-based unsustainability towards post-fossil sustainable development.[2] This is based on the expert reports by the German Advisory Council on Global Change (*Wissenschaftlicher Beirat der Bundesregierung Globale Umwelt, WBGU*) (*WBGU* 2011, 2016a),

Global environmental changes are the point of departure for the expert report by the German Advisory Council on Global Change (2011). At the same time, the Advisory Council goes beyond ecology and systematically incorporates the economy, politics and society. Because of the magnitude of the required transformation, which is described in more detail in the expert report using the example of climate change, the Advisory Council searched for a foundation. This was found in Polanyi's work *The Great Transformation* (1978 [1944]). The Advisory Council introduced the Great Transformation as a heuristic concept (cf. section 2.3). The statements on the fundamental transformation areas – energy transition, urbanisation, land use and global governance for infrastructure development – offer great potential for spatially-relevant transformation research.[3] The 2011 expert report dealt with different concepts of change management (e.g. the MLP approach). In the follow-up report (*WBGU* 2016a) on the 'Unlocking the transformative power of cities', which has thus far received less attention in transformation research on sustainability, the Advisory Council presented its own conceptualisation, which can be used in spatially-relevant transformation research.

The German Advisory Council on Global Change proposes a conception of the Great Transformation towards sustainability which goes beyond ecology. For example, the consideration of planetary guidelines is linked to questions of power, i.e. it is not approached purely naturalistically. The '*Eigenart*' category (a German word meaning 'individual character') to describe the spatial diversity of cities, introduced in the Advisory Council's normative compass, is particularly interesting for spatial transformation research. Unsustainability is the point of departure for the Advisory Council's work on the sustainability transformation.

Another line of transformation research emphasises the connection between social and ecological issues. Accordingly, the transformation towards sustainability is also characterised as a socio-ecological transformation. The handbook entitled *Die sozial-ökologische Transformation der Welt* [The socio-ecological transformation of the world] (K.-W. Brand 2017) illustrates this using the concept of society-nature rela-

2 Which frequently focus on climate change. The keyword *decarbonisation* has entered linguistic usage as a strategic orientation. I do not use this term, since it is objectively inaccurate: without carbon, there is no life. Carbon is the basic element of organic processes. Instead, the term 'post-fossil' describes the actual issue better (for the significance of framing and reframing, see Lakoff/Wehling 2012; Wehling 2016; Held 2016a).

3 In contrast to the discussion on the MLP approach, this potential has not yet been given sufficient attention. For example, the Advisory Council's excellent work on the development of conceptual perspectives in spatial transformation is not incorporated due to the exclusion criterion (*peer-reviewed*) (Levin-Keitel/Mölders/Othengrafen et al. 2018).

tionships. This strand of research analyses structural driving forces, the contradictory interests of different actors and conflicts (section 4.2). The controllability of fundamental transformations is not a prerequisite but rather a part of the analysis of transformation dynamics (section 5.2).[4]

2.3 The Great Transformation towards sustainability

As mentioned above, the concept of the Great Transformation originates in Karl Polanyi's seminal work *The Great Transformation. Political and economic origins of societies and economic systems* (1978 [1944]). He focused on the historically singular emergence of a market society in the 18th and 19th centuries, and introduced the concept of a 'Great Transformation' to describe this. He treats commercialisation as part of the overarching development of a market society and the Industrial Revolution (Held 2016b). The disembedding of the economy from nature and society is a fundamental characteristic for him. Disembedding and re-embedding processes are a focal point of space-related research on the Great Transformation which has great potential.

The transition from fossil-based unsustainability towards post-fossil, sustainable development is comparable in its scope with the emergence of market society or the Industrial Revolution. Various classifications are used in the literature: for example, Sieferle (2010) compares the magnitude of the transformation facing us with that of the Neolithic Revolution, as well as the Industrial Revolution. Additionally, he includes the use of fire as another fundamental transition in human history. In other studies, the development of language, the emergence of nation states, European colonisation and the scientific-technological revolution are described as comparably fundamental transitions (Takács-Sánta 2004).

In accordance with its significance for human history, the pending Great Transformation towards sustainability is sometimes written in capital letters. In contrast with the Industrial Revolution, which started in the United Kingdom, this transformation is not starting in a specific country or region of the earth, but is worldwide. The programmatic part of the UN's Sustainable Development Goals (SDGs) refers to this peculiarity: all countries are now transformation countries in this sense, but with very different circumstances, problems and potentials (UN 2015). The timescale of the incipient Great Transformation is shorter than the previous transformations in human history. Yet, despite all the acceleration dynamics, it is a discrete historical phase which will probably last for at least two generations.

4 Unfortunately, due to space constraints I am unable to go into further differentiations in this brief introduction, for example between transformation research and transformative research (Schneidewind/Singer-Brodowski 2013).

3 Space-specific transformation research – time-conscious

3.1 Spatial transformation – space, place, scale

Space, place, scale – these categories mark the research on the geography of sustainability transitions (Truffer/Murphy/Raven 2015; Hansen/Coenen 2015; Levin-Keitel/Mölders/Othengrafen et al. 2018). This is a line of research which is strongly anchored in economic geography, but at the same time unites a broad range of approaches, specific research questions and numerous case studies, with a focus on the spatial dimensions of the sustainability transformation:

> *Space*: A distinction is made between different spatial concepts. There is evidence for the advantages of physical proximity in clusters, as well as for the significance of culturally or socio-culturally determined spaces. These may be advantageous or, conversely, detrimental to socio-technological innovations towards sustainability. To some extent, outdated dichotomies remain potent in research (e.g. nature – culture), and spaces are sometimes conceptualised in their interactions in the sense of society-nature relationships (Levin-Keitel/Mölders/Othengrafen et al. 2018).

> *Place*: This could be paraphrased as follows: *contexts may matter*. Several case studies demonstrate that the specifics of particular 'places' (*place* is used to describe very different geographical units) can be essential for the understanding of transition processes. I am phrasing this cautiously because, considering the dynamic of the development of interrelationships, this is not simply a given. Therefore, it is not only individual 'places' or regions that are examined; rather, the relationship between places can be just as decisive. This becomes evident in the development of the concept of proximity: for transition processes, geographical proximity may be important; in other cases, proximity via professional networks, networks of municipalities and other actors, or socio-cultural networks may be decisive (Truffer 2016).

> *Scale*: In agreement with a lot of other research on the sustainability transformation, the question of scale or levels is fundamental. Some studies on the *geography of sustainability transitions* embraced the idea that a particular level – e.g. cities or regions – is more important for transition processes towards sustainability than other levels. There is now a stronger emphasis on analysing the interaction between different levels and actors.

This direction of research is influenced by ongoing unsustainable processes and their consequences (climate change, etc.), as well as by initial transformation steps, particularly in the energy system. The influence of the MLP approach is also intrinsic to this research; in many studies, it serves as a reference point and as a means to structure the study. Just as influential is its strong orientation towards socio-technological innovations (for example, in the programmatic part of the journal *Environmental Innovation and Societal Transitions*). Occasionally, studies on the geography of sustainability transitions refer to the role of infrastructures (for example, in research on energy technologies) and, in connection with this, landscapes.

Other lines of research, particularly those on the foundation of spatial and landscape planning, place the shaping of landscapes, and therefore the role of infrastructures, at the centre.

The above mentioned overviews argue in favour of differentiating between fundamental concepts (conceptualisation of space, etc.), as well as incorporating influential factors such as power and normative questions such as justice to a greater degree. Despite all the differences, there is agreement about the basic question (paraphrased in my words): What significance do local or spatial contexts have for transition processes towards sustainability in an age which is defined by a strong development dynamic and space-time compression?

3.2 Times – spaces

Transition processes occur in physical spaces, they change socio-cultural spaces, weaken networks and create new connections. The transformation towards sustainability is played out in time, through processes with their own development speeds (accelerating, decelerating), different phases, path dependencies and structural ruptures.

In transition research towards sustainability which specifically considers spatial dimensions, a frequent criticism is that these dimensions are not explicitly treated in more detail. In a complementary way, one might note that in the geography of sustainability transitions, temporalities are often used ad hoc without being explicitly conceptualised. Indeed, spatial transformation research gains from being time-conscious and from taking *temporalities* seriously (for space–time, see Hofmeister 2006).

For example, in the energy transition, the rhythm of renewable energies is highlighted as a disadvantage by many actors. In a *framing* which is geared towards controlling nature and is characterised by the time theft of the accelerated consumption of fossil energy deposits formed over millions of years, this fossil disembedding from the natural context is imagined forward into the post-fossil age. Space-related, time-conscious transformation research develops appropriate new frameworks (*reframing*). Accordingly, natural rhythms are not understood a priori purely as *constraints*; rather, processes of production and reproduction, or production cycles, are considered to be part of the transformation.

Time is not simply linear, comprising uniform time units, but encompasses temporalities as a whole: acceleration, inherent time (*eigenzeit*), speed, rhythm, sensitive time, timing, deceleration, forms of time, time policy, time scales, time values, time affluence (cf. the Tutzing project 'Ecology of time' [*Ökologie der Zeit*]; e.g. Held/Geißler 1995, 2000; Adam/Geißler/Held 1998; Held/Hofmeister/Kümmerer et al. 2000; Geißler/Kümmerer/Sabelis 2006; cf. also Reisch/Bietz 2014).

Timescape – the concept introduced by Adam (1998, 1999) – is particularly important for spatial research. This approach conceptualises the multi-dimensionality of time:

> Duration/period

> Processes/change

> Speed

> Past – present – future

> Timing

In her analysis, Adam (1998) refers to *time lags* of different lengths, latency times, and initially invisible effects which only become visible in other places with a time delay. This refers not only to common instances such as the half-lives of nuclear fuel rods in relation to societal timescales such as legislative periods and planning horizons, but also to numerous comparable processes of shaping landscapes, the development of spatial and settlement structures, transport, energy and other infrastructures.

The German translation of *timescapes* would be *Zeitschaften*. However, as this sounds unusual in German, we translate *timescapes* in the Tutzing project as *Zeitlandschaften* (Hofmeister/Spitzner 1999). The distinction between 'timescapes', 'land-scapes' and 'time-landscapes' is productive for spatially focused transformation research. The Federal Nature Conservation Act [*BNatSchG*], for example, speaks generally of landscape protection. In actual practice, this is geared towards the protection of day landscapes, while transitions to night landscapes are only included in individual cases on an ad hoc basis (Haber 2013; Held/Hölker/Jessel 2013; *SRU* [German Advisory Council on the Environment] 2018).

The use of the fossil trio (coal, petroleum, natural gas) has increasingly greatly influenced the development of landscapes, both directly and indirectly, since the beginning of the Industrial Revolution. Comparably fundamental is the question of the appropriate shaping of post-fossil landscapes in the actual transformational changes towards post-fossil, sustainable development (Held 2018).

Wind, solar power and energy from renewable resources have the advantage that they can be used decentrally. This brings the question of how the landscape – in the sense of an energy landscape – is shaped back onto the agenda (Hofmeister/Scurrell 2016). The question of how to mix centrally and decentrally produced renewable energies is put into concrete terms by the scaling of the transmission networks on which it depends (for the overlapping of landscapes and hybridisations of urban landscapes, see Schöbel 2018; Hofmeister/Kühne 2016; Kühne/Bruns 2015).

The shaping of landscapes in the sustainability transformation by no means occurs simply on the basis of measures for climate protection and the energy transition towards renewable energies. In its statement on large-scale insect protection, the German Advisory Council on the Environment (*SRU*) (2018) ascribes the serious loss

of biodiversity in part to the large-scale impoverishment of landscape structures. It shows that measures for insect protection must be coordinated with the development of the energy transition, for example the expansion of wind turbines. It is precisely such tasks of shaping the landscape and spatial planning, which do not point in the same direction for all criteria of the sustainability transformation (i.e. they entail *trade-offs*), that are interesting for both research and practice, and simultaneously challenging.

4 The Great Transformation towards sustainability – conceptualisation

4.1 Transformation – form of time transition and space-time scales

Transformation, in a temporal view, is a form of time (on forms of time: Held 2004; Hatzelmann/Held 2010: 113 et seq.). Transitions – in contrast to forms of time such as the start, the end and waiting – contain a temporal and a spatial aspect. For example, mountain passes characterise spatial transitions.

Transitions can range from very small to very large space and time scales. Transformations are examined on different scales in transformation research on sustainability. As shown, the analysis of transformation towards sustainability leads to the classification of it in terms of human history on an overarching scale, comparable with the Neolithic Revolution or the Industrial Revolution, for example. The term 'Great Transformation' has therefore not been invented out of thin air but is the result of the analysis of the subject being studied. As in these reference examples, it is a historically singular transition.

The understanding of the Great Transformation towards sustainability as a transitional form of time is heuristically useful: transitions denote temporal changes from a 'before' to an 'after'. This makes it clear that the analysis of transformation has three fundamental, connected parts: *before – transition – after*. Transformation, when understood as a transition, makes it clear that the opposite of sustainable is unsustainable. This is emphasised by a core element of the concept of 'the Great Transformation towards sustainability': *the point of departure is fossil-based unsustainability*. That means that this development is not future-viable on a permanent basis. The longer the transition is delayed and the more actively it is counteracted, the more difficult it becomes to shape the transformation in a fair and acceptable way, and the more serious are the ruptures and distortions (see, for example, Hirsch/Bezdek/Wendling 2005: Chapter 3 'Why transition will be time consuming').

For the analysis of transformation and the transformative processes, it is useful not simply to characterise the *before* in a generalising way as being equivalent to 'unsustainable'. Rather, a deeper analysis reveals that in their degree of unsustainability, individual countries, social strata and economic sectors have progressed to different levels ('developed' according to the previous understanding). At the same time, differences also exist despite the basic fossil-based character of all societies (cf. above on *varieties of capitalism*). For example, some global regions, countries and cities are more extremely dependent on fossil petroleum than others. This diversity is significant

for the transformational processes, since there are transformatively usable specific examples in some areas in the direction of sustainability (for example, the difference between Portland, Oregon and other American cities of a comparable size).

Figure 2 represents the basic scheme of the Great Transformation towards sustainability in a simplified form (see Fig. 2 without phasing-in and phasing-out).

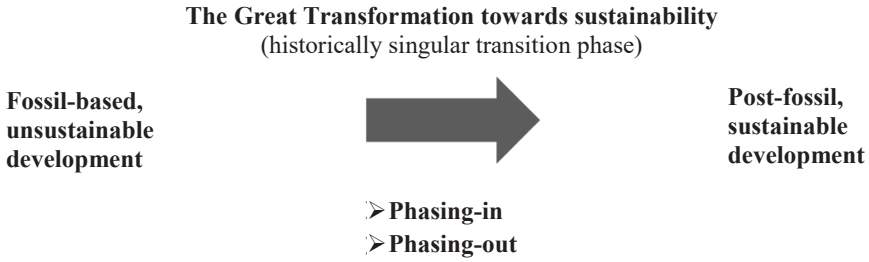

Fig.2: The Great Transformation towards sustainability – expanded basic scheme with phasing-in and phasing-out / Source: modified from Schindler/Held/Würdemann 2009: 137

4.2 Phasing-in and phasing-out

In transformation research, attention was directed for many years almost exclusively towards innovations in the direction of sustainability, particularly towards socio-technological innovations. This is, indeed, an important part of the sustainability transformation. However, it also neglected significant aspects of the developments. In the last few years, in addition to innovations, the question of the development of previously dominant, unsustainable structures, technologies and lifestyles has been addressed. In accordance with the focus on socio-technological innovations towards sustainability, the notion of 'exnovation' is often used here. Exnovations are part of the overarching phasing-out.

To analyse transformation, a categorical differentiation between phasing-in and phasing-out *is heuristically advantageous*. The current actors, interests and structures will not disappear 'by themselves'. Rather, an active phasing-out of unsustainable structures, institutions, infrastructures, etc. is just as important as an active phasing-in of innovations towards a sustainable development (cf. Fig. 2).

'The phasing-in and phasing-out processes occur simultaneously.
They are often fractured, surprising, wayward and have their own dynamics.
New actors come into play, incumbents put up resistance or
attempt to transform themselves in turn.
New coalitions and changing constellations of actors are on the agenda'
(Bauriedl/Held/Kropp 2017: 6).

This differentiation brings essential questions for transformational processes into view, which are outside the frame when innovation processes alone are considered. The withdrawal from lignite in Germany is a prime example of phasing-out (*SRU* 2017). It is virtually a classic example of the consequences of delaying and actively counteracting a phasing-out. This makes the transition more difficult and creates problems in shaping the phasing-out in a socially acceptable way.

The distinction between phasing-out and phasing-in is crucial with regard to natural gas as part of the fossil trio. In the context of the energy transition or transformation research towards sustainability, the idea often prevails that all fossil energies must be cut back and the energy system must be completely converted to renewable energies. However, this leaves essential questions unanswered, as shown by the example of gas: is the natural gas infrastructure to be completely written off (phasing-out)?[5] Or can this infrastructure – possibly retrofitted to some degree – be used for a renewable energy system and thus become part of a phasing-in? This shows us that an understanding of the interaction between phasing-out and phasing-in can be productive for an acceptable and sweeping transformation towards sustainability. With regard to natural gas and renewable gas (including hydrogen), the question of whether it is possible to move from fossil natural gas to renewable sources is raised – metaphorically speaking, 'new wine in old bottles'? This is not just a question confronting the shareholders in the natural gas economy; rather, this applies to all actors in the energy transition and raises questions such as the sector coupling of electricity and gas networks (Frontier economics/IAEW/FourManagement et al. 2017; *Agentur für erneuerbare Energien* [Renewable Energy Agency] 2018). These questions affect a central component of the energy transition with considerable spatial consequences, which is not yet in the focus of policy and planning. Furthermore, what about the phasing-out of other parts of fossil-based infrastructures, spatial and settlement structures and their utilisation for phasing-in?

4.3 Interactions between multifaceted processes

In addition to this first distinction between phasing-in and phasing-out, the analysis of transformational processes as a foundation for debates and activities to promote the Great Transformation can benefit by a further differentiation of the basic scheme. A proposal for discussion for this can be found in Figure 3.

5 This is no peripheral issue. In Germany alone, there are over 700,000km of natural gas pipelines, if micro-distribution to end consumers is taken into account.

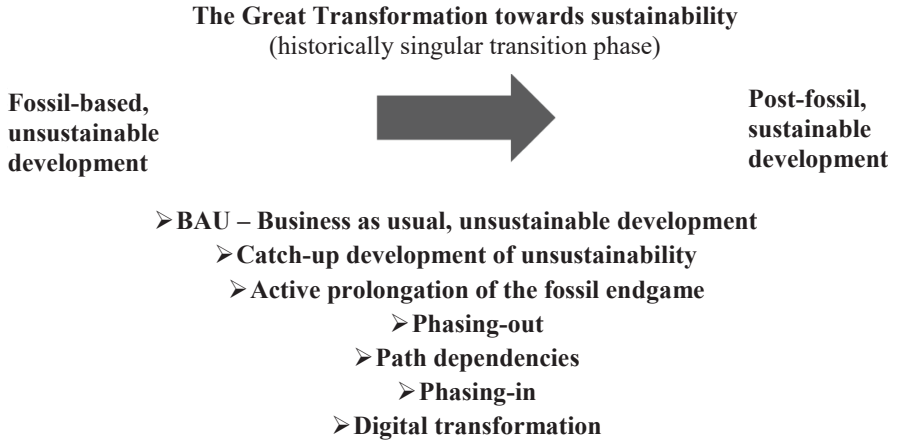

Fig. 3: The Great Transformation towards sustainability – differentiated scheme / Source: the author

> *BAU*: The fundamental trend of *business as usual* towards unsustainability will not be broken suddenly (metaphorically 'overnight'). Rather, the status quo worldwide generally carries on as before, even if radical changes loom: for example, when extreme weather conditions become more frequent in the process of climate change and become drastically perceptible, and the production of conventional petroleum has reached a plateau.

> *Catch-up development of unsustainability*: In countries which are not yet as comprehensively fossil-based as the industrialised nations, the process of catch-up development of unsustainability is continuing, despite extreme problems such as large-scale air pollution, water scarcity and much more.

> *Active prolongation of the fossil endgame*: It can be plausibly assumed that not all relevant actors in the previously dominant development model of unsustainable development (in simplified terms: *incumbents*) will simply write off their assets and vacate their previous basic position without complaint. It is equally unlikely that citizens will simply give up their habits and *vested interests* and stand up for the strengthening of the sustainability transformation as *citoyens*, independently of their personal interests. Rather, it should be expected that some actors will pursue an active prolongation of the fossil endgame. The corresponding changes to the law in the US, with the subsequent ramping-up of the production of unconventional petroleum via fracking technologies, are a striking example of this. This specific example alone changes the actual course and conditions of the energy transition, since it wastes valuable adjustment time. Worldwide. The transition becomes rougher (Hirsch/Bezdek/Wendling 2005).

> *Phasing-out*: The significance of active phasing-out has already been explained.

> *Path dependencies*: the consequences of the climate change caused thus far, fossil-based spatial and settlement structures, transport infrastructures, post-mining landscapes, but also institutions, methods of transport route planning and the prevailing transport policy in most countries, as well as fossil-based *mental models* can be very potent and multifaceted (Denzau/North 1994).

> *Phasing-in*: This encompasses institutional, social and socio-technological innovations. A preeminent example would be the Renewable Energy Act (*Erneuerbare-Energien-Gesetz, EEG*) in Germany. It is equally important to disseminate positive examples from the time of predominantly fossil-based development and to make them contagious in a transformative way. This can also be understood as transformatively usable path dependencies. These are not innovations but rather the active dissemination of existing practices and structures. There are diverse examples at the city level (for less fossil-dependent urban structures on a human scale, cf. Gehl 2010). The advantage is that such examples are already visible and can be experienced as a nucleus for transitions.

> *Digital transformation*: We, the people in industrialised nations, are currently experiencing the beginning of the end of the fossil-based world as we know it and which has decisively shaped previous developments towards unsustainability (modification of a song title by R.E.M. from 1987: *It's the end of the world as we know it*). At the same time, we are at the beginning of the digital transformation, which means that the Great Transformation towards sustainability is occurring under different conditions from those that would have applied without this digital transformation.

I have already indicated the large number of potential interactions between the various developments and influencing factors.

5 Themes and differentiations

5.1 Power, interests, actors, conflicts, justice

Stimulating niche innovations for renewable energies is one thing. The other, equally important thing is to destabilise the previous dominance of fossil energy and to actively enforce its dismantling. This is not a statement by critics of the MLP approach to sustainability transition management. Rather, it is the core message and analytic focus of one of the most influential representatives of this approach (Geels 2014). He accordingly believes that it is productive to introduce power and political economy into this approach.

This corresponds to the differentiation of the analytical scheme which I have proposed. At the same time, this shows that the different approaches are not necessarily contradictory; rather, they have different analytical focuses and can be further developed. Space-related transition research should, correspondingly, include power in its analyses to a greater degree (Truffer/Murphy/Raven 2015; cf. *WBGU* 2016a; see Fig. 4).

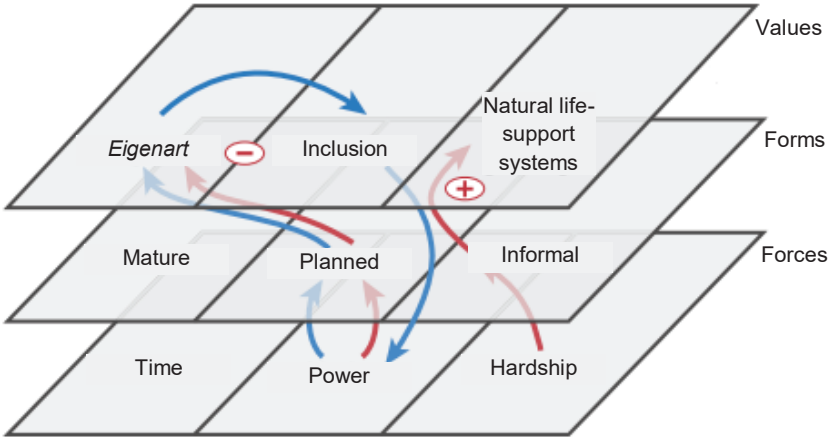

Fig. 4: Schematic diagram showing dominant global settlement patterns (forms), their drivers (forces) and their challenges in relation to the WBGU's 'normative compass' (values) / Source: WBGU 2016a: 5, 37

This does not lessen the importance of pioneers of change (Kristof 2010; *WBGU* 2011). However, an analysis of actors should count on a diversity of actors. For example, it should be expected that, on the one hand, influential actors will support and promote the energy transition to some degree, but on the other hand, they will also simultaneously slow it down and even partially thwart it. This could be metaphorically described as a kind of 'Bavarian oath'. These actors actively reframe the debate by asserting that 'The energy transition must retain security of supply and be affordable'. Thus, the energy transition is factually, and in some cases probably also intentionally, slowed down and capped. This is not simply a theoretical possibility; it is not difficult to attribute this to existing actors in reality.

Actors such as large businesses, for example, may fight actively for a prolongation of the fossil endgame; they may, at one and the same time, carry on with *business as usual* in some countries and participate in the development of renewable energy in other areas. This recalls the association with the Duke in Visconti's film *The Leopard*:

> *'Everything must change so that everything can remain the same'*
> (from the film based on Tomasi di Lampedusa's *The Leopard* 1959).

A simple subdivision into *incumbents* and sustainability pioneers does not do justice to this.

Given the radicality, reach and momentousness of a thorough transformation towards post-fossil, sustainable development, conflicts are unavoidable. The Great Transformation cannot be brought about by a single (miracle) instrument which is efficient on paper under *ceteris paribus* conditions and across all systems – changing 'everything'. In simplified terms, we might refer to this as emission certificates in an ideal world. An impartial analysis of the various interests in their complexity is much more useful.

The interests, in turn, are not fixed. An essential lever for the formation of a critical mass for components of the sustainability transformation may be, for example, that interest in innovations (for example, wind power) grows *rapidly enough* through participation in the corresponding cooperatives or revenues from shares, causing the balance of power to shift.

However, it can also be effective to actively disseminate a framing of freedom in the discourses circulating in society: the freedom from dependency on fossil energies. This can be used to shine a positive light on measures to limit climate change.

The Great Transformation towards sustainability does not come about of its own accord; it does not directly emerge from the results of scientific research and a 'rational' policy based on it. This cannot happen. Rather, scientific findings enter the crossfire between different interests, conflicts and escalating crises.

Anyone who seriously addresses the singularity of the Great Transformation towards sustainability in human history and understands its momentousness as being comparable with the Neolithic Revolution and the Industrial Revolution should not just speak generally of intergenerational and intragenerational justice. Rather, a transformation towards sustainability only progresses if the full momentousness of the justice question is taken seriously and, in so doing, the social and ecological sides are not separated but addressed in their interrelationship (*WBGU* 2016b; K.-W. Brand 2017, U. Brand 2016; Brie 2014). This is truly challenging.

5.2 Planning and controllability of transformation processes

> *'Great Transformation processes cannot be comprehensively planned.* […]
> *However, it is possible to conceive transformations which*
> *contain elements which are shaped in an anticipatory,*
> *scientifically-supported way'*
> (Sturn 2017: 36).

In relation to spatial planning and spatial structuring, the shaping of landscapes and urban landscapes, questions of the extent to which transition processes can be planned and controlled on different scales are obviously raised. As stated, the MLP approach was originally designed for the management and micro-management of niche innovations. Given the momentousness of a fundamental reversal away from unsustainability towards sustainable development, this is discussed intensively (e.g. Stirling 2014, but see also representatives of the approach itself, e.g. Geels 2014).

A distinction must be made, put simply, between the management of individual socio-technological innovations on a small scale and the question of how the fundamental reorganisation of fossil-based unsustainability into post-fossil sustainable development can be planned and controlled. I regard the discussion about windows of oppor-

tunity and the connection between basic findings (e.g. on climate change) and the required discussions about normative specifications to be productive (Strunz 2017).

5.3 Energy transition, mobility transformation, raw material transformation – building blocks of the Great Transformation

Until this point, the main focus of my article has been on the subject in question: 'the Great Transformation towards sustainability'. In the process, I have cited examples of various aspects of the nature of the Great Transformation.

Another approach would be to focus on specific building blocks of the Great Transformation towards sustainability. These components are, in turn, already powerful in a social, economic, political and cultural sense.

In my preliminary assessment, the Great Transformation towards sustainability began historically[6] with the first steps towards an energy transition in the direction of an energy system based completely on renewable energy. It is therefore no coincidence that most of the research thus far has focused on questions about this part of the Great Transformation. Space-related transformation research is sorely needed here, since the departure from the fossil/nuclear energy regime towards renewable energy is directly reflected in space and in the landscape.

At the same time, this example demonstrates a core aspect of the Great Transformation: unsustainability cannot be perpetuated indefinitely. However, this does not result in an automatism in the direction of a very particular form of the energy transition as a component of transformation. For example, the mixture of centrally and decentrally produced electricity is by no means 'given', nor is the structure of the heating market. Likewise, the structure of the development path towards renewably produced hydrogen is also not 'given'.

The mobility transformation (sometimes also described as the transport transformation, e.g. Agora Verkehrswende 2017; Held/Schindler 2012) comes somewhat later than the energy transition. The energy transition, after initial attempts, is now spreading worldwide as a concept and challenge for politics (*energy transition*). The mobility transformation is now gradually entering the public debate in Germany. This component of the Great Transformation not only faces technological challenges (which have thus far dominated policy); there are also fundamental spatial-temporal dimensions: speed, distance, space – and particularly the question of the allocation of public space and the shaping of urban landscapes, as well as infrastructures. With the notion of the *friction of distance* (also sometimes known as the *friction of space*: Rodrigue 2017) has provided an important concept for space-related transformation research on the mobility transformation.

6 Historical periods can only be constructed and such historical processes can only be dated with any certainty from a temporal distance.

Whereas energy as a prerequisite for economic activity and mobility as an essential prerequisite for economic activity and of 'the good life' have already attracted attention in relation to the Great Transformation, the material prerequisites have not yet been brought into the discourse to an extent that corresponds to their momentousness (not even in relation to the digital transformation; see section 6). This is related to conceptual and path-dependent effects: the 'energy transition' is immediately understandable, as is the 'mobility transformation'. The 'raw material transformation', on the other hand, requires explanation, because the term is not necessarily intuitively comprehensible.

A starting point for the necessarily rapid initiation of this area of transformation is provided by metals. In a nutshell: *post-fossil is possible* and urgent. *Post-metal is not possible*; rather, metals are becoming even more important in the sustainability transformation and in the digital transformation (Exner/Held/Kümmerer 2016; Held/Schindler 2017; Held/Jenny/Hempel 2018).

The associated questions and problems are as similarly challenging for space-related transformation research as they are for the energy transition and the mobility transformation. This is particularly interesting for countries such as Germany, in which ore mining, smelting and metallurgy played a formative role for long periods of time, but where the metal deposits are now emptied and ore mining no longer takes place, or only to a minimal extent. Thus metals are now only directly visible in the landscape where they are actually being used. The landscapes here are connected with the landscapes in other places, where ore mining and the metal industry are operated on an increasingly large scale. Withdrawal from this, such as is urgently required in the case of lignite for climate protection reasons, is not generally possible here.[7]

6 Digital transformation and the Great Transformation towards sustainability

The digital transformation is developing in chronological parallel to the beginnings of the Great Transformation towards sustainability. This on its own, without taking into account reciprocal effects with the sustainability transformation, is massively changing time and space relations. Unfortunately, I cannot go into this further at this point.

The relationship with digitalisation or the digital transformation has been a subject of transformation research on sustainability for some years now. Usually, this focuses on certain aspects – for example, the potential of smart grids, an improvement in traffic flow management and the like. The possible advantages of the use of digitalisation for the sustainability transformation are particularly strongly emphasised (code word for this: smart, and in some cases also 'intelligent'). As a possible counter-effect, reference is usually made to possible rebound effects (Lange/Santarius 2018). This view also prevails in the line of research which looks from the perspective of the digital transformation to possible connections with the sustainability transformation

7 For further building blocks of the Great Transformation towards sustainability, see Schneidewind (2018), who refers to them as arenas. In the field of agricultural transformation, there is a new biannual publication series: *Agricultural Transformation Review*

(e.g. Scholz 2016; Schieferdecker/Messner 2018; Scholz/Bartelsman/Diefenbach et al. 2018; *WBGU* 2018): in this view, digitalisation tends to be advantageous for sustainability transformation, while potential rebound effects must be kept as minimal as possible. This framing of the connection between the digital transformation and the sustainability transformation seems at first glance to be intuitive, since the digital world often appears to be virtual, entirely free from materials and consuming only minimal energy (key word: *intangibles*).

Occasional exceptions can be found, for example when the energy consumption of blockchain encryption technology becomes a topic of ad hoc public discussion. In applied research, partly together with actors from NGOs, the first publications have appeared which address the connection between the two transformations in a more systematic way (e.g. Iddri/FING/WWF France et al. 2018). These directly address energy and other resources as a prerequisite for digital technologies.

But even in these exceptions, the massive material dynamic set off by the digital transformation has not yet been addressed in all its momentousness: *digital transformation requires the functionalisation of the entire periodic table* (including around 75% metals and around 5% of semi-metals). Without the increasingly massive use of metals and semi-metals*, there would be no digitalisation*. The vast majority of metals used in digital devices are *dissipated* – dispersed and wasted, since the way they are mixed, often in small or very small quantities, virtually rules out recycling after use. They are used up and lost to humankind. This reveals a further fundamental component of the Great Transformation, which must be urgently analysed and actively addressed (on the relationship between the Great Transformation towards sustainability and digital transformation, see Held/Jenny/Hempel 2018: 232 et seq.).

7 Perspective – re-embedding the economy

Space, place, scale – it has become clear that the spatial focus can directly contribute to transformation research. If one enumerates the spatial perspective in relation to the energy transition, mobility transformation and the sustainable handling of metals as essential components of the Great Transformation, it becomes clear how essential this is. This involves nothing less than transformation from a fossil-based to a post-fossil configuration encompassing landscape, space and settlement structures, sealing and soil degradation, transport and other infrastructures. This is all extremely challenging for spatial planning, the shaping of the landscape, urban development, multi-level governance and much more.

In his analysis of the development of market society, Polanyi mapped out the *disembedding of the economy* from other parts of the living environment, society and culture as a major aspect of this Great Transformation. And, going beyond this, he already – in 1944! – identified the danger of the destruction of the 'natural environment' (Polanyi 1978 [1944]: 108 and other pages) as a consequence of this disembedding. Anyone studying the challenge of the Great Transformation towards sustainability which is facing us is advised to study Polanyi on *disembedding* and *re-embedding*. For more in-depth information, a biography of Polanyi is recommended (Dale 2016).

The Great Transformation towards sustainability does not simply require a lengthening of the prevailing development path using different means: 'Fossil energies out – renewable energies in', and otherwise a continuation of the control of nature, dissipation and waste. Rather, a fundamental re-embedding of the economy is needed. We already made this point in 1994 in our study of economists' understanding of nature. The opening words of our article in full:

> *'What we are currently simultaneously experiencing,*
> *and the subject of this book, are the*
> ***very beginnings of the next Great Transformation:***
> *a developed market society must be further developed in a way*
> *that permanently guarantees the ecological and social prerequisites*
> *for economic activity;*
> *or, to put it another way, that enables the emergence of a*
> ***new form of embedded economy'***
> (Biervert/Held 1994: 25; emphasis in the original).

References

Adam, B. (1998): Timescapes of Modernity. The Environment & Invisible Hazards. London/New York.
Adam, B. (1999): Naturzeiten, Kulturzeiten und Gender – zum Konzept 'Timescape'. In: Hofmeister, S.; Spitzner, M. (Eds.): Zeitlandschaften. Perspektiven öko-sozialer Zeitpolitik. Stuttgart/Leipzig, 35-57.
Adam, B.; Geißler, K. A.; Held, M. (Eds.) (1998): Die Nonstop-Gesellschaft und ihr Preis. Vom Zeitmißbrauch zur Zeitkultur. Stuttgart/Leipzig.
AEE– Renewable Energy Agency (2018): Die Rolle erneuerbarer Gase in der Energiewende. Berlin.
Agora Verkehrswende (2017): Mit der Verkehrswende die Mobilität von morgen sichern. 12 Thesen zur Verkehrswende. Berlin.
Bauriedl, S.; Held, M.; Kropp, C. (2017): Große Transformation zur Nachhaltigkeit – Grundlagen zum konzeptionellen Verständnis. ARL Working Group 'Sustainable Spatial Development for the Great Transformation'. Hanover. = Arbeitspapier ARL.
Biervert, B.; Held, M. (1994): Veränderungen im Naturverständnis der Ökonomik. In: Biervert, B.; Held, M. (Eds.): Das Naturverständnis der Ökonomik. Beiträge zur Ethikdebatte in den Wirtschaftswissenschaften. Frankfurt/New York, 7-29.
Brand, K.-W. (Ed.) (2017): Die sozial-ökologische Transformation der Welt. Ein Handbuch. Frankfurt/New York.
Brand, U. (2016): Sozial-ökologische Transformation. In: Bauriedl, S. (Ed.): Wörterbuch Klimadebatte. Bielefeld, 277-282.
Brie, M. (Ed.) (2014): Futuring. Perspektiven der Transformation im Kapitalismus über ihn hinaus. Münster.
Dale, G. (2016): Karl Polanyi. A Life on the Left. New York.
Denzau, A. T.; North, D. C. (1994): Shared Mental Models: Ideologies and Institutions. In: Kyklos 47 (1), 3-31.
Elzen, B.; Geels, F. W.; Green, K. (Eds.) (2004): System Innovation and the Transition to Sustainability. Theory, Evidence and Policy. Cheltenham/Northampton MA.
Engel, T.; Knieling, J. (2018): 'Große Transformation' und nachhaltige Raumentwicklung – Stand der Diskussion und theoretische Zugänge. In: Knieling, J. (Ed.): Wege zur großen Transformation. Herausforderungen für eine nachhaltige Stadt- und Regionalentwicklung. Munich, 13-31.
Exner, A.; Held, M.; Kümmerer, K. (Eds.) (2016): Kritische Metalle in der Großen Transformation. Berlin/Heidelberg.
Frontier Economics; IAEW; FourManagement; EMCEL (2017): Der Wert der Gasinfrastruktur für die Energiewende in Deutschland. Eine modellbasierte Analyse. Cologne.
Geels, F. W. (2011): The Multi-Level Perspective on Sustainability Transitions: Responses to Seven Criticisms. In: Environmental Innovation and Societal Transitions 1 (1), 24-40.

Geels, F. W. (2014): Regime Resistance against Low-Carbon Transitions: Introducing Politics and Power into the Multi-Level Perspective. In: Theory, Culture & Society 31 (5), 21-40.
Geels, F. W.; Schot, J. (2010): The Dynamics of Transitions: A Socio-Technical Perspective. In: Grin, J.; Rotmans, J.; Schot, J. (Eds.): Transitions to Sustainable Development. New Directions in the Study of Long Term Transformative Change. New York/London, 9-101.
Gehl, J. (2010): Cities for People. Washington/Covelo/London.
Geißler, K. A.; Kümmerer, K.; Sabelis, I. (Eds.) (2006): Zeitvielfalt. Wider das Diktat der Uhr. Stuttgart.
Grin, J.; Rotmans, J.; Schot, J. (Eds.) (2010): Transitions to Sustainable Development. New Directions in the Study of Long Term Transformative Change. New York/London.
Haber, W. (2013): Taglandschaften und Nachtlandschaften. In: Held, M.; Hölker, F.; Jessel, B. (Eds.): Schutz der Nacht – Lichtverschmutzung, Biodiversität und Nachtlandschaft. Bonn, 19-22. = BfN-Skripten 336.
Hall, P. A.; Soskice, D. (Eds.) (2001): Varieties of Capitalism. The Institutional Foundations of Comparative Advantage. Oxford.
Hansen, T.; Coenen, L. (2015): The geography of sustainability transitions: Review, synthesis and reflections on an emergent research field. In: Environmental Innovation and Societal Transitions (17), 92-109.
Hatzelmann, E.; Held, M. (2010): Vom Zeitmanagement zur Zeitkompetenz. Weinheim/Basel.
Held, M. (2004): Zeit nehmen für Zeitformen. In: Thedorff, A. (Ed.): Schon so spät? Zeit. Lehren. Lernen. Stuttgart, 330-343.
Held, M. (2016a): Framing als Analysemodell und Gestaltungsfrage. In: Arch+ Zeitschrift für Architektur und Städtebau (222), 60-63.
Held, M. (2016b): Große Transformation – von der fossil geprägten Nichtnachhaltigkeit zur post-fossilen nachhaltigen Entwicklung. In: Held, M.; Kubon-Gilke, G.; Sturn, R. (Eds.): Politische Ökonomik großer Transformationen. Marburg, 323-352. = Jahrbuch 15 Normative und institutionelle Grundfragen der Ökonomik.
Held, M. (2018): Große Transformation zur Nachhaltigkeit – fossile Prägungen und postfossile Landschaften. In: Schöbel, S. (Ed.): Land-Schafts | Vertrag. Zur kritischen Rekonstruktion der Kulturlandschaft. Berlin, 132-144.
Held, M.; Geißler, K. A. (Eds.) (1995): Von Rhythmen und Eigenzeiten. Perspektiven einer Ökologie der Zeit. Stuttgart.
Held, M.; Geißler, K. A. (Eds.) (2000): Ökologie der Zeit. Vom Finden der rechten Zeitmaße. 2nd Edition. Stuttgart.
Held, M.; Hofmeister, S.; Kümmerer, K.; Schmid, B. (2000): Auf dem Weg von der Durchflußökonomie zur nachhaltigen Stoffwirtschaft. Ein Vorschlag zur Weiterentwicklung der grundlegenden Regeln. GAIA – Ecological Perspectives for Science and Society 9 (4), 257-266.
Held, M.; Hölker, F.; Jessel, B. (Eds.) (2013): Schutz der Nacht – Lichtverschmutzung, Biodiversität und Nachtlandschaft. Bonn, 13-16. = BfN-Skripten 336.
Held, M.; Jenny, R. D.; Hempel, M. (Eds.) (2018): Metalle auf der Bühne der Menschheit. Von Ötzis Kupferbeil zum Smartphone im All Metals Age. Munich.
Held, M.; Schindler, J. (2012): Verkehrswende – wann geht's richtig los? In: Wende überall? Von Vorreitern, Nachzüglern und Sitzenbleibern. Stuttgart, 38-48. = Jahrbuch Ökologie 2013.
Held, M.; Schindler, J. (2017): All Metals Age: Die postfossile Gesellschaft braucht alle Elemente des Periodensystems. In: GAIA – Ecological Perspectives for Science and Society 26 (4), 305-308.
Hirsch, R. L.; Bezdek, R.; Wendling, R. (2005): Peaking of World Oil Production: Impacts, Mitigation, & Risk Management. = Report for the US Department of Energy. www.netl.doe.gov/publications/others/pdf/oil_peaking_netl.pdf (07 Oct 2018).
Hofmeister, S. (2006): Alles zu gleicher Zeit am gleichen Ort? Verdichtung von Raum und Zeit: das Ende der 'Verinselung'. In: Geißler, K. A.; Kümmerer, K.; Sabelis, I. (Eds.): Zeitvielfalt. Wider das Diktat der Uhr. Stuttgart, 97-112.
Hofmeister, S.; Kühne, O. (Eds.) (2016): StadtLandschaften. Die neue Hybridität von Stadt und Land. Wiesbaden.
Hofmeister, S.; Scurrell, B. (2016): Die 'Energielandschaft' als StadtLandschaft. Die Transformationsgeschichte einer Region in sozial-ökologischer Perspektive. In: Hofmeister, S.; Kühne, O. (Eds.): StadtLandschaften. Die neue Hybridität von Stadt und Land. Wiesbaden, 187-214.
Hofmeister, S.; Spitzner, M. (Eds.) (1999): Zeitlandschaften. Perspektiven öko-sozialer Zeitpolitik. Stuttgart/Leipzig.

Iddri; FING; WWF France; GreenIT.fr (2018): White Paper Digital Technology and Environment. Paris.
IPCC – Intergovernmental Panel on Climate Change (2018): Global Warming of 1.5°C. Summary for Policymakers. Geneva. = IPCC Special Report.
https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_SPM_version_report_LR.pdf (02 Sep 2021).
Kemp, R.; Schot, J.; Hoogma, R. (1998): Regime Shifts to Sustainability through Processes of Niche Formation: The Approach of Strategic Niche Management. In: Technology Analysis and Strategic Management 10, 175-196.
Kristof, K. (2010): Wege zum Wandel. Wie wir gesellschaftliche Veränderungen erfolgreicher gestalten können. Munich.
Kühne, O.; Bruns, D. (2015): Gesellschaftliche Transformation und die Entwicklung von Landschaft. Eine Betrachtung aus der Perspektive der sozialkonstruktivistischen Landschaftstheorie. In: Kühne, O.; Gawronski, K.; Hernik, J. (Eds.): Transformation und Landschaft. Die Folgen sozialer Wandlungsprozesse auf Landschaft. Wiesbaden, 17-34.
Lakoff, G.; Wehling, E. (Eds.) (2012): The Little Blue Book. The Essential Guide to Thinking and Talking Democratic. New York/London/Toronto/Sydney/New Delhi.
Lange, S.; Santarius, T. (2018): Smarte Grüne Welt. Digitalisierung zwischen Überwachung, Konsum und Nachhaltigkeit. Munich.
Levin-Keitel, M.; Mölders, T.; Othengrafen, F.; Ibendorf, J. (2018): Sustainability Transitions and the Spatial Interface: Developing Conceptual Perspectives. In: Sustainability 10 (6). doi:3390/su10061880.
Merkel, W. (2010): Systemtransformation. An introduction to the theory and empiricism of transformation research. 2nd revised and expanded edition. Wiesbaden.
National Research Council (2000): Our Common Journey. A transition toward sustainability. Board on Sustainable Development. Policy Division National Research Council. Washington D.C.
Polanyi, K. (1978 [Orig. 1944]): The Great Transformation. Politische und ökonomische Ursprünge von Gesellschaften und Wirtschaftssystemen. Frankfurt am Main.
Reisch, L. A.; Bietz, S. (2014): Zeit für Nachhaltigkeit – Zeiten der Transformation. Mit Zeitpolitik gesellschaftliche Veränderungsprozesse steuern. Munich.
Rockström, J.; Steffen, W.; Noone, K.; Persson, Å.; Chapin III, F.S.; Lambin, E.; Lenton, T.M.; Scheffer, M.; Folke, C.; Schellnhuber, H.; Nykvist, B.; De Wit, C.A.; Hughes, T.; van der Leeuw, S.; Rodhe, H.; Sörlin, S.; Snyder, P.K.; Costanza, R.; Svedin, U.; Falkenmark, M.; Karlberg, L.; Corell, R.W.; Fabry, V.J.; Hansen, J.; Walker, B.H.; Liverman, D.; Richardson, K.; Crutzen, C.; Foley, J. (2009): A safe operating space for humanity. In: Nature 30 (461), 472-475.
Rockström, J.; Steffen, W.; Noone, K.; Persson, A.; Chapin III, F.S.; Lambin, E.; Lenton, T.M.; Scheffer, M.; Folke, C.; Schellnhuber, H.; Nykvist, B.; De Wit, C.A.; Hughes, T.; van der Leeuw, S.; Rodhe, H.; Sorlin, S.; Snyder, P.K.; Costanza, R.; Svedin, U.; Falkenmark, M.; Karlberg, L.; Corell, R.W.; Fabry, V.J.; Hansen, J.; Walker, B.; Liverman, D.; Richardson, K.; Crutzen, P.; Foley, J. (2009b): Planetary Boundaries: Exploring the Safe Operating Space for Humanity. In: Ecology and Society 14 (2), 32.
Rodgrigue, J.-P. (2017): The Geography of Transport Systems. 4th Edition. New York.
Schieferdecker, I.; Messner, D. (2018): Die digitalisierte Nachhaltigkeitsgesellschaft. In: Mair, S.; Messner, D.; Meyer, L. (Eds.): Deutschland und die Welt 2030. Was sich verändert und wie wir handeln müssen. Berlin.
Schindler, J.; Held, M.; Würdemann, G. (2009): Postfossile Mobilität. Wegweiser für die Zeit nach dem Peak Oil. Bad Homburg.
Schneidewind, U. (2018): Die Große Transformation. Eine Einführung in die Kunst gesellschaftlichen Wandels. Frankfurt am Main.
Schneidewind, U.; Singer-Brodowski, M. (2013): Transformative Wissenschaft. Klimawandel im deutschen Wissenschafts- und Hochschulsystem. Marburg.
Schöbel, S. (Ed.) (2018): Land-Schafts | Vertrag. Zur kritischen Rekonstruktion der Kulturlandschaft. Berlin.
Scholz, R. W. (2016): Sustainable Digital Environments: What Major Challenges is Humankind Facing? In: Sustainability 8 (8), 726. doi:10:3390/su8080726.
Scholz, R.W.; Bartelsman, E.J.; Diefenbach, S.; Franke, L.; Grunwald, A.; Helbing, D.; Hill, R.; Hilty, L.; Höjer, M.; Klauser, S.; Montag, Chr.; Parycek, P.; Prote, J.Ph.; Renn, O.; Reichel, A.; Schuh, G.; Steiner, G.; Pereira, G.V. (2018): Unintended Side Effects of the Digital Transition: European Scientists' Messages from a Proposition-Based Expert Round Table. In: Sustainability 10 (6), 2001. doi:10.3390/su10062001.

Sieferle, R. P. (2010): Lehren aus der Vergangenheit für die Transformation zu einer klimafreundlichen Gesellschaft. Expertise für das WBGU-Gutachten 'Welt im Wandel: Gesellschaftsvertrag für eine Große Transformation'. Berlin.
https://www.researchgate.net/profile/Rolf-Sieferle/publication/303898940_Lehren_aus_der_Vergangenheit_Expertise_fur_das_WBGU-Hauptgutachten_Welt_im_Wandel_Gesellschaftsvertrag_fur_eine_Grosse_Transformation/links/575be72908aed8846212e8bd/Lehren-aus-der-Vergangenheit-Expertise-fuer-das-WBGU-Hauptgutachten-Welt-im-Wandel-Gesellschaftsvertrag-fuer-eine-Grosse-Transformation.pdf (02 Sep 2021).
SRU – German Advisory Council on the Environment (2017): Start coal phaseout now. Statement. Berlin.
SRU – German Advisory Council on the Environment; Advisory Board on Biodiversity and Genetic Resources at the BMEL (2018): Für einen flächenwirksamen Insektenschutz. Berlin/Bonn. Statement 8 October 2018.
https://www.umweltrat.de/SharedDocs/Downloads/DE/04_Stellungnahmen/2016_2020/2018_10_AS_Insektenschutz.pdf?__blob=publicationFile&v=12 (11 Oct 2018).
Stirling, A. (2014): Emancipating Transformations: From Controlling 'the Transition' to Culturing Plural Radical Progress. Brighton. = STEPS Working Paper 64.
Strunz, S. (2017): Transformation zur Nachhaltigkeit – Herausforderung für Diskurs und Theorie. In: Hirschbrunn, K.; Kubon-Gilke, G.; Sturn, R. (Eds.): Kapitalismus, Globalisierung, Demokratie. Marburg, 351-376. = Jahrbuch 16 Normative und institutionelle Grundfragen der Ökonomik.
Sturn, R. (2017): Kapitalismus, Globalisierung, Demokratie: Große Transformationen und das Politische. In: Hirschbrunn, K.; Kubon-Gilke, G.; Sturn, R. (Eds.): Kapitalismus, Globalisierung, Demokratie. Marburg, 13-41. = Jahrbuch 16 Normative und institutionelle Grundfragen der Ökonomik.
Takács-Sánta, A. (2004): The Major Transitions in the History of Human Transformation of the Biosphere. In: Human Ecology Review 11 (1), 51-66.
Tomasi di Lampedusa, G. (1959): Der Leopard. Munich.
Truffer, B. (2016): The Geography of Sustainability Transitions. *Think/act, globally/locally*. Inaugural lecture. Utrecht.
Truffer, B.; Murphy, J. T.; Raven, R. (2015): The geography of sustainability transitions: Contours of an emerging theme. In: Environmental Innovation and Societal Transitions (17), 63-72.
UN – United Nations (2015): Transforming our World: The 2030 Agenda for Sustainable Development. New York.
WBGU – German Advisory Council on Global Change (2011): World in Transition. A Social Contract for Sustainability. Flagship Report. Berlin.
WBGU – German Advisory Council on Global Change (2016a): Humanity on the move: Unlocking the transformative power of cities. Flagship Report. Berlin.
WBGU – German Advisory Council on Global Change (2016b): Development and justice through transformation: The Four Big 'I's. Special Report. Berlin.
WBGU – German Advisory Council on Global Change (2018):
Digitalization: What we need to talk about. Berlin.
Wehling, E. (2016): Politisches Framing. Wie eine Nation sich ihr Denken einredet – und daraus Politik macht. Cologne.

Author

Martin Held (*born 1950*), *Dr. at the University of Augsburg. Lecturer and then senior lecturer at the Tutzing Protestant Academy for Economy and Sustainable Development (Evangelische Akademie Tutzing für Wirtschaft und nachhaltige Entwicklung) from 1984 to 2015. Initiator and chair of 'Transformers – active towards sustainability transformation'. Member of the ARL Working Group 'Sustainable Spatial Development for the Great Transformation'. Freelancer at the Tutzing Protestant Academy.*