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About this text

Most of the sustainability solutions developed today are forward-looking innovations ranging from technological to social. These solutions often focus on technology, which prompts calls for pragmatic and inclusive transformational change especially in communities that cannot afford high-technology. Taking inspiration from E.F. Schumacher's longstanding call for the use of intermediate technologies that are better suited to local conditions, the concept of sustainability archaeology is introduced where both material and immaterial solutions from the past could be used to solve sustainability problems of today. Corollary to this is a proposed concept of tempocoupling, which extends the idea of telecoupling, to explore interrelationships among distant interactions and feedbacks not only across space but also through time. Taken together, tempocoupling could be a framework that could be used in an emerging field of sustainability archaeology.

Zu diesem Text

Bei den meisten der heute entwickelten Nachhaltigkeitslösungen handelt es sich um zukunftsweisende Innovationen, die von technologischen bis hin zu sozialen Fragen reichen. Diese Lösungsansätze konzentrieren sich oft auf Technologie, was den Ruf nach pragmatischen und integrativen transformativen Veränderungen auslöst, insbesondere in Gesellschaften, die sich hochtechnologische Lösungen nicht leisten können. Ausgehend von E.F. Schumachers langjähriger Forderung nach dem Einsatz von Zwischentechnologien, die besser an die lokalen Bedingungen angepasst sind, wird in diesem Beitrag das Konzept der Nachhaltigkeitsarchäologie vorgestellt, bei dem sowohl materielle als auch immaterielle Ansätze aus der Vergangenheit zur Lösung von Nachhaltigkeitsproblemen der Gegenwart genutzt werden könnten. In diesem Zusammenhang wird das neue Konzept des *tempocoupling* vorgestellt, welches die Idee des *telecoupling* aufgreift und erweitert. Die Idee ist, Wechselbeziehungen zwischen entfernten Regionen und Rückkopplungen nicht nur über den Raum, sondern auch über die Zeit hinweg zu betrachten. Zusammengenommen könnte die Idee des *tempocoupling* ein Konzept sein, das in einem aufstrebenden Bereich der Nachhaltigkeitsarchäologie verwendet werden könnte.

Content

Introduction

The adoption of the 2030 Agenda for Sustainable Development brought the sustainability agenda further to the forefront, more than two decades after the first Rio conference on environment and development. With all sectors of society weighing in and identifying ways to contribute to "transforming" the world, the research field of sustainability science has taken up the challenge of understanding mechanisms and patterns underlying sustainability transformations with the help of conceptual frameworks such as transition management and resilience theory (Olsson et al. 2014). While the two frameworks may have fundamental differences with transition management focusing on socio-technological systems and resilience theory focusing on social-ecological systems, both conceptual frameworks are forward-looking when it comes to crafting transformative changes towards sustainability. This "progressive" attribute of both transition management and resilience theory is often associated with charting new directions or new trajectories and undertaking experiments that could lead to unexpected innovations. The path to sustainability might, therefore, be paved with cutting edge results.

Innovations for transformational change have a broad spectrum of definitions ranging from technological to social. Distinctions between top-down high-technology and bottom-up grassroots innovations have also been made, highlighting the need for transformational change to be pragmatic and inclusive (Leach et al. 2012). Grassroots innovations are similar to what E.F. Schumacher (1973) has called "intermediate technology" in his book "Small is Beautiful," which has long since become a classic. Both authors emphasize the need for innovations and technologies to be appropriate and suited to local conditions. In addition, resilience scholars also caution against innovations that fail to take ecological integrity into consideration as these could potentially offset sustainable development gains and reinforce the path towards unsustainable development (Olsson 2014). One such example could be biofuel innovations such as jatropha, which Balkema and Pols (2015) conclusively describe as irresponsible innovations given the loss of land and the loss of income for those farmers who were contracted to plant them. Looking for alternatives to carbon-intensive fuels, foreign investors such as companies from the European Union made large-scale investments in developing countries to plant jatropha as biofuels for export purposes. Undesirable impacts on a local scale were facilitated by decisions made on a global level, which goes to show how important it is to consider multi-scale interconnections and interactions in the sustainability agenda.

Multi-scale interconnections have been defined by the concept of "telecoupling". As an umbrella concept, telecoupling encompasses various distant interactions such as international trade or land use change and explores the interrelationships among these interactions as well as feedbacks across multiple scales (Liu et al. 2013). Similar to transition management and resilience theory, telecoupling is quite progressive by often focusing on distant environmental and socioeconomic interactions. However, there are

also interconnections on a temporal scale with impacts reverberating through time. Often, these are captured in studies dealing with "historical" impacts or dynamics, which could explain social-ecological lock-ins or traps and other sustained social-ecological phenomena. This article proposes the concept of "tempocoupling" with the aim to broaden telecoupling by explicitly including temporal feedbacks. Tempocoupling could be particularly useful for problem framings and could work in conjunction with discovering sustainability solutions from the past. Taken together, these two could constitute "sustainability archaeology" - an emerging topic in archaeology (e.g. Mendoza 2014) that could potentially become a new research branch of sustainability science that looks to the past to explain the present in order to rediscover sustainable solutions for the future. Sustainability archaeology can be seen as an interface between geobiodiversity and social ecology. Geobiodiversity is an integrative systemic approach to natural history research that is primarily rooted in the natural sciences while social ecology is derived from a social science perspective where societies regulate their relationships with nature (CETAF 2017; ISOE 2020). Archaeology, specifically its subfields such as environmental archaeology or landscape archaeology (or landscape history), unites these two perspectives and looks at the relationship that societies have with their environment from the perspective of both the social and natural sciences. In the following sections, several concepts explaining the present in relation to the past are reviewed. The final section puts together these concepts and proposes a theoretical model of tempocoupling and sustainability archaeology.

The extended present and the relativity of simultaneity

> *"In the course of time, the events of the universe succeed each other in an orderly way: pasts, presents, futures. The past is fixed, the future open ... And yet all of this has turned out to be false."*
>
> *– Carlo Rovelli, The Order of Time*

Among all scientific fields except horology or the science of time, physics is probably the one discipline that has most thoroughly studied the topic of time in relation to space. Quantum physics offers great inspiration when it comes to the development of concepts concerning tempocoupling. However, the use of these concepts from physics should not be taken as an appropriation used out of the original context and will hopefully not be considered an affront to a field that has developed theories that painstakingly yet beautifully define the fundamental workings of our physical world. One such theory is Einstein's Theory of Relativity, which provides metaphors through which tempocoupling could be understood. As Gödel (1949) explains, the very starting point of special relativity is the discovery of relativity of simultaneity. As a property of time, the relativity of simultaneity implies that the temporal ordering of two spatially separated or distinct events occurring at the same time is not absolute ("loses its objective meaning") but depends on an event observer's "reference frame" (Gödel 1949; Saudek 2019). Extended to tempocoupling, the relativity of simultaneity invites a thorough

analysis of the perspective or "reference frame" by which events and phenomena are scrutinized or judged. By being mindful of reference frames, tempocoupling draws insights from multiple perspectives in analysing sustainability problems or in envisioning sustainability solutions.

When impacts of events or phenomena reverberate through time, causing temporal interconnectedness between the commonly termed "then" and "now", the "extended present" from the theory of relativity (also called expanded present) corresponds as a fitting analogy. The quantum gravity theorist Carlo Rovelli (2018) explains that a well-defined "now" is an illusion and "an illegitimate extrapolation of our own experience" and he defines the extended present as a set of events that are neither past nor future. He further explains that a single, universal distinction between past, present, and future cannot represent all the events in the universe and their temporal relations. Appropriating the extended present as yet another metaphor for tempocoupling, what could be seen as a present phenomenon could, in reality, be an extension of an event from the past. If present phenomena are analyzed through tempocoupling by decoding their connection to past events and their evolution, it could well be that sustainability interventions not only adapt to scale but also to time (Boonstra and de Boer 2014). This is also reflected in the work of Friis and Nielsen (2017) on land use change in Laos, when they concluded that the more recent economic and political telecouplings in the country need to be put into a longer temporal perspective by taking into account the history of the state, including territorialization and upland development. Sustainability has historical roots: the present and future of any system can only be understood within the context of past structures and processes (Tainter 2002). It is within this perspective that tempocoupling gets involved in addressing sustainability questions.

Historical sociology and path dependency

To a certain extent, far-reaching impacts during the course of time have been studied in a broad range of disciplines whether in hydrology (e.g. Whitehead and Robinson 1993) or psychology (e.g. Evans-Campbell 2008). Often referred to in literature as "historical impacts", temporal interconnectedness underpins many studies but has yet to be fully explored in sustainability research as an explanatory variable. One study that attempts to do so is the work of Boonstra and de Boer (2014), which systematically analyses the historical origin and temporal sequence of events that produce social-ecological traps. Social-ecological traps are persistent mismatches of social-ecological conditions and the ecological or social responses they trigger, which are a function of the interdependent interactions between people and their environment (Boonstra and de Boer 2014; Boonstra et al. 2016). One example provided by Boonstra and de Boer (2014) is the dryland poverty trap in Makanya, Tanzania where degraded ecosystems persist despite efforts to raise crop yields, which consequently lead to chronic poverty for the people. In order to understand this mechanism, they used Mahoney's (2000) path dependency as an analytical concept. Rooted in the field of historical sociology,

Mahoney's (2000) path dependency examines historical sequences in which contingent or chance events trigger institutional patterns or event chains that have deterministic properties. These historical sequences are either self-reinforcing (i.e. developing a long-term reproduction of a certain institutional pattern) or reactive (i.e. with chains of temporally ordered and causally connected events). Self-reinforcing sequences may be synonymous to positive feedback loops in systems thinking, while reactive sequences are similar to causal determinism as studied in philosophy. The study of Boonstra and de Boer (2014) compared four social-ecological traps and identified distinct phases through which the traps came about. In their study, they conclude that historical analysis and the identification of causal mechanisms can help identify leverage points (in the form of human agency) by which traps can be prevented or reversed.

Envisioning tempocoupling in sustainability science requires an appropriation of the elements of path dependency and historical sociology. Tempocoupling looks to the past to explain the present and to imagine the future. Like telecoupling, tempocoupling aims to provide a greater understanding of the "increasingly invisible threads," connecting the present to the past (Hull and Liu 2013). Tempocoupling could be useful in both "descriptive-analytical" and "transformational" research streams of sustainability science. Wiek and Lang (2016) noted how the phrase "addressing sustainability" is loaded and unpacked how "addressing sustainability problems" could either fall under the problem-oriented descriptive-analytical type of sustainability research or the solution-oriented transformational type. Methodologically, the descriptive-analytical research stream normally uses systems thinking and modeling while the transformational stream uses frameworks such as complex problem handling (DeTombe 2001), transition management and governance (Rotmans et al. 2001; Loorbach 2010), backcasting (Robinson 2003), and transdisciplinary case study (Wiek and Lang 2016). Wiek and Lang (2016) also described a framework called TRANSFORM that incorporates features of the transformational stream frameworks. Of specific interest for tempocoupling is TRANSFORM's "foresight" element, which aims to analyze past and current states of sustainability problems. This may be useful in assessing socio-technical changes especially in the transition management field, namely, socio-technical landscape, regimes, and niches (Rotmans et al. 2001). What is, however, missing from all these frameworks is information on how to utilize the past when searching for sustainability solutions for the present or the future. The past should not only be probed to look for culprits of present-day problems; the past is also a source of innovations as shoulders of giants that people have stood on and could still potentially stand on. Being able to derive solutions or innovations from the past would correspond to the solution-oriented transformational stream of sustainability research. These innovations from the past could also have an "extended present" should they prove to be helpful and applicable to current conditions. All these and, perhaps, more are what sustainability archaeology could provide and further explore in the field of sustainability science.

Sustainability archaeology

> *"Archaeology is not history armed with a spade, but a detective story in which the investigator has arrived at the scene a thousand years late. History is pronounced later by judges. So you must decide: to go in for one or for the other"*
>
> *– Leo S. Klejn as quoted in Laurance (2004)*

Some might ask, "Why sustainability archaeology and not sustainability history or applied historical ecology?" While acknowledging that this might appear to be a "chicken and egg" debate between history and archaeology, proposing sustainability archaeology has the aim of capturing both material and immaterial evidence of the past and does not intend to take sides. It has been said that history reveals how problem-solving develops over time, while archaeology can trace this development over extremely long periods and among societies that left no written records, being the only field that can conduct an "exclusive investigation of material culture" (Tainter 2002; Sauer 2004). Archaeology is a means by which the intersections of natural and social environments can be studied at multiple scales through time and across space (Rockman and Hritz 2020). It is a broad field that offers the possibility to identify technologies, practices, institutions, and knowledge from the past by contextualizing society alongside the environments they live in. By proposing sustainability archaeology, we suggest to look to the past for both immaterial insights and material clues of how, for example, societies persisted for a sustained period of time until they collapsed or alternatively evolved into their present state. A case study of the Maya lowlands shows that artifacts like shrines and ball courts located even in very small communities bear witness to a "niche specialization" that enabled the creation of a network of barter or exchange based on regional or area-specific resources such as food or building supplies of each "specialized" community (Scarborough 2009). The ancient Maya's arrangement of "small, dispersed, but numerically abundant" communities somewhat exemplifies what E.F. Schumacher advocates in Small is Beautiful (Scarborough 2009). In the aggregate, these communities create a strong network and could be described as "different baskets," taking after a line from Miguel de Cervantes Saavedra's *Don Quixote* stating that, "It is the part of a wise man to (...) not venture all his eggs in one basket" (Perfold 2004). Specialization paves the way for diversification and we learn that these small, linked communities in the Maya lowlands were resilient because of stheir successful adaptation and long-term survival by way of open interdependencies among each other (Scarborough 2009). Other examples can be found in the manner through which hunter-gatherer populations changed their ways of mobility and land use as a response to an increasing water table caused by the inundation of the North Sea during the Pleistocene-Holocene transition (Crombé et al. 2011) or how technology in the form of toolkits were used by aboriginal Australians to minimize the risk of environmental change (Hiscock 1994).

Much of the interest in archaeology or environmental studies dealing with the past is focused on past failures and disasters. It can be argued, however, that successes of the past are of equal importance especially since these pre-industrial traditional successes developed over thousands of years of trial and error (Fitzpatrick and Keegan 2007; Guttmann-Bond 2010). Traditional practices still have a place in modern-day life as is demonstrated in a paper aptly entitled, "Sustainability out of the past: How archaeology can save the planet" in which the author enumerates several intermediate technologies that can help in rural development (Guttmann-Bond 2010). As mentioned earlier in this text, the term "intermediate technologies" has been introduced by E.F. Schumacher to describe a technology that is more productive than an indigenous one but is significantly cheaper than the highly-capital intensive technologies of modern industry. Engineers refer to intermediate technologies as technologies from the past that are sustainable, have little or no reliance on fossil fuels, and use local materials (Guttmann-Bond 2010). The world we live in today is imbued with technotasking and/or the desire to live as comfortably as possible with the help of technological breakthroughs, which are often linked to a rapid and exploitative use of resources that leaves sizable segments of society behind and vulnerable to abject poverty and social-ecological degradation (Scarborough 2009). Solutions can only be sustainable as long as they include all strata of society and do not exist for the exclusive use of a select group of people. The hope is that sustainability archaeology can make it possible to identify inclusive solutions that worked in the past with the potential to work for the present through the study of material and immaterial clues.

Operationalizing tempocoupling and sustainability archaeology

Mongolia's political transition to democracy demonstrates elements of tempocoupling and sustainability archaeology. The dissolution of the socialist system of Mongolia in the 1990s has far-reaching impacts that can still be felt to date, especially impacting livelihoods of pastoralist herders. With the perspective of pastoralist herders as a "reference frame", life during the socialist era was better than a democracy that forces them to sell raw materials and produce on the free market (Wagner 2016). During the socialist era, they could sell products as part of a socialist collective, with livestock numbers as well as pasture use regulated. In the current democratic system, pasture use has been deregulated, with livestock numbers increasing and, thus, contributing to pasture land degradation. These problems are well-known and development interventions have aimed to address them by taking a leaf out of Mongolia's book of socialist past. One of the notable interventions is the concept of Pasture User Groups (PUGs) introduced by the Swiss Agency for Development and Cooperation (SDC), which aims to mimic the socialist collective and undertake actions such as joint pasture management, hay making, and small enterprise development (Fernández-Giménez et al. 2015). While mimicking the socialist collective is mostly drawing from the immaterial past, it

still demonstrates the rationale behind sustainability archaeology of how the past could contribute to the present and potentially also to the future. Using the pastoralist herders as "reference frame", we see that tempocoupling can facilitate an understanding of ecosystem services and their evolution within a social-ecological system. Herding is both a provisioning and cultural ecosystem service. However, the weight and priority of each ecosystem service has changed through time with political transitions as one of the triggers. This shows how the supply and demand for ecosystem services are regulated by a troika of spatial, temporal, and social dynamics (Mehring et al. 2018).

Operationalizing tempocoupling and sustainability archaeology requires insights from both natural and social sciences, especially from social ecologists, sustainability scientists, archaeologists, and historians. That there is a broad spectrum of subfields such as historical ecology and historical sociology, landscape history, or anthropological archaeology containing elements of the concepts introduced here shows that it is well worthwhile to look to the social-ecological past, whether it be to explain the present or to look further ahead for solutions for today and tomorrow. In any system of problem-solving, early strategies that work and give higher returns per unit of effort are adopted before more complex and expensive ones (Tainter 2002). Sustainability archaeology aims to do just that and dig out these early strategies that could still contribute to solving sustainability challenges of today. Using the tempocoupling lens, there are ancient practices, technology, knowledge, institutions or even values that are enjoying an "extended present," such as innovations from former times or stories passed on from generation to generation that are still used by societies today. Conversely, there are also problems of today that are tempocoupled with decisions or events from the past (e.g. Unnikrishnan et al. 2020) and could only be fully understood by having a comprehensive grasp of the changes that led to these problems. With this paper I hope to catalyze further discussions on and consideration of the past not only by providing lessons but also solutions for sustainability research. As has often been touted by the field of international development, collaboration is necessary for solving sustainability problems. In the case of sustainability archaeology, an interdisciplinary cooperation among fields that as a general rule rarely meet such as history, archaeology, and ecology may hold the key to decoding the sustainable past in order to create a sustainable present and future.

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