Co-constructing Dynamic thick / Deep Maps for Doing Transformative Transdisciplinary Research (TTDR) in the Context of Complex Sustainability Transitions

John van Breda
Centre for Sustainability Transitions (CST), Stellenbosch University, Stellenbosch, South Africa

Email address: jrvb@sun.ac.za

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Abstract: Embarking upon sustainability transitions from an unsustainable towards a more sustainable world is a complex undertaking which cannot be approached with one-size-fits-all approaches (panaceas). The social and institutional arrangements necessary for performing this double-movement, inherent in all sustainability transitions, never takes place within exactly the same set of (universal) conditions, but rather under radically different contextual conditions. Ontologically speaking, it is possible to distinguish at least three fundamentally different kinds of sustainability transitions namely: clear, complicated and complex transitions – each with its own internal transitioning logics and dynamics – warranting different methodological approaches. The consequences of approaching all transitions as if they were essentially the same, with one-size-fits-all methodologies, runs the risk of falling into the trap of path-dependency – i.e. becoming (permanently) locked into pursuing certain dominant – single-track – transitioning pathways, regardless of the contexts in which the transitions are embedded. One way of avoiding this is through methodological agility (MA) – a meta-level research strategy which has purposely been developed for knowing when and how to switch between mono-, multi-, inter- and trans-disciplinary research approaches when facing said ontologically different kinds of transitions. The purpose of this paper is to focus specifically on complex transitions and some of the key methodological challenges we face when dealing with the emergence and subsequent fluidity of these challenges. As a starting point, performing the double movement in complex transitioning processes means / implies dealing with multiple non-linear transitioning pathways between ill-defined current and future states as opposed to more linear transitioning pathways between well-defined current and future states when dealing with clear and complicated situations. However, the prospect of facing the complexity of complex transitioning challenges can quite easily be construed as things being overly complex to deal with, especially at a practical level of working with real-world sustainability transitions. Overcoming this concern will be addressed in this paper by introducing the co-constructing of dynamic thick / deep maps as an appropriate practical, research method for being methodologically agile when performing TTDR.

Keywords: Path-Dependency, Transitioning Pathways, Complexity, Equiprobability, Non-Linearity, Transformative Trans-Disciplinarity, Thick / Deep Maps, Agile Synergetic Methods

1. Introduction

Embarking upon sustainability transitions from an unsustainable to a more sustainable world is indeed a complex undertaking which cannot be tackled with one-size fits-all methodologies (panaceas) which approach all sustainability transitions in the same manner – thereby falling into the trap of path-dependency [2, 29, 43]. The fundamental purpose of this paper is to make a methodological contribution to avoid such path-dependency by tackling the challenge of sustainability transitions as part and parcel of the polycrisis [58, 59] – a complex set of interconnected human-induced changes to certain earth systems – e.g. climate, water, soil systems etc. A fundamental feature of the polycrisis is that there is no single, dominant crisis – e.g. climate change – to which all the other
crises can be reduced. In the context of the Anthropocene [15, 18, 83] the polycrisis has indeed become a global crisis – with unprecedented life-threatening consequences for the continued existence of human civilization on earth, as we know it. It is when facing the polycrisis – as multiple tightly coupled crises – that we are compelled to come up with some innovative methodological responses from within academia to avoid said panaceas and path-dependencies – indeed the main aim of this paper.

With this broad methodological purpose in mind, the more specific objectives of this paper are three-fold, namely to:

1) Presenting methodological agility (MA) as a meta-level research strategy capable of dealing with radically different kinds of sustainability transitions in the polycrisis, with a specific interest in tackling complex sustainability transitions.

2) Undertaking transformative transdisciplinary research (TTDR) with an express interest in not only the understanding (Verstehen) and explaining (Erklärung) the complexity of complex sustainability transitions, but also in changing (Verändern) them.

3) Co-constructing dynamic thick / deep maps as a practical, appropriate research method for being methodologically agile, whilst doing TTDR.

This undertaking implies new methodological research work which, to my knowledge, has not yet been undertaken systematically – a gap this paper intends to fill.

To achieve the above-mentioned objectives, the following modus operandi will be followed:

Starting from the premise that not all sustainability transitions in the polycrisis are necessarily complex, Section 1 will introduce at least three radically different kinds of sustainability transitions, namely: clear, complicated, and complex transitions. This will then be followed up by a discussion in Section 2 on MA as an appropriate meta-level research strategy for dealing with said contextually different kinds of sustainability transitions. In Section 3 the focus will be on adopting TTDR as an appropriate methodological response when facing sustainability transitions that are too complex for dealing from within academia only, thereby warranting some societal stakeholder engagement, with some explicit human and knowledge interests [34] in not only understanding (Verstehen) or explaining (Erklärung) the complex transitioning challenges facing us today, but also changing (Verändern) them. In Section 4 the focus will shift to the more practical level of working with appropriate research methods for doing TTDR by introducing the notion of co-constructing thick / deep maps. This will be done by explicating some of the key aspects hereof, namely what are thick vs deep maps¹; how can the latter be co-constructed in a methodologically agile manner whilst, at the same time, contribute to the transformative purposes of TTDR. Section 5 will build on this by presenting some of the practical tools that can be used for co-constructing and visualizing thick / deep maps. However, the tools featured in this section should not be seen as some or other definitive list of all the tools available for this task at hand, but rather just as some examples of what is available and, more importantly, how they can be used for visualising and co-constructing said thick / deep maps. Section 6 will then conclude by pointing out some of the aspects that were not explicitly addressed in the paper, and which will be further pursued in future TTDR work.

2. Contextually Different Sustainability Transitions

As mentioned earlier, not all sustainability transitions encountered in the polycrisis are necessarily complex. Some are indeed complex, others clear / straightforward and others complicated. Deciding on which transitions are complex, and which are not, should not be construed as merely engaging some or other ‘semantic games’, as it were, because of the far-reaching decision-making and action-taking consequences flowing from the different ways and means of defining and understanding these radically different kinds of sustainability transitions. These decisions always need to be discussed, negotiated, and agreed upon between the participants in TTDR processes, in / under specific contextual conditions.

The conceptual distinctions of clear, complicated, and complex transitions, each with their own internal transitioning dynamics, can be further elucidated on by referring to the different kinds of contexts in which they are embedded. These can be graphically depicted as follows:

2.1. Clear Transitions

Are characterized by single, linear transitioning pathways:

![Figure 1. Signifying single linear, straightforward transitioning pathways.](Source: Self-generated.)

Clear sustainability transitions involve straightforward, single-track pathways in situations where both the current unsustainable and future sustainable states are well-defined as well as the linear step-like² processes for moving from the former to the latter. In such cases, there are normally well documented extant theoretical and practical knowledges available to guide how to successfully perform the transitioning process via the correct application of some tried and tested procedures, never to be deviated from but to be implemented exactly as prescribed by the available expert knowledge. In such situations, working with the knowledge generated and documented in mono-disciplinary research
practices are considered sufficient for performing the linear transitions at hand, with no need to engage or consult with any social stakeholders.

2.2. Complicated Transitions

Are characterized by multiple, linear transitioning pathways:

![Figure 2. Signifying multiple linear, straightforward transitioning pathways.](Image)

Complicated sustainability transitions involve multiple linear transitioning pathways when facing situations where both the current and future states remain well-defined, but the question of how to move from the former to the latter can certainly be undertaken in more than one way. Exactly which of these different (linear) pathways should be pursued is not immediately clear and is certainly not something which can be resolved by mono-disciplinary approaches only. It, therefore, warrants that disciplinary experts from the relevant disciplines start engaging with each other in multi- and inter-disciplinary approaches for determining which of the multiple (linear) transitioning pathways should be pursued certain cases, multiple pathways in parallel.

2.3. Complex Transitions

Are characterized by multiple, non-linear transitioning pathways:

![Figure 3. Signifying multiple non-linear transitioning pathways.](Image)

Complex sustainability transitions are dealing with multiple unknown unknowns [94] which are simply too complex to be approached from within academia only, thus, warranting engaging with relevant societal stakeholders in trans-disciplinary research approaches. For our purposes, unknown unknowns refer to both ill-defined current and future states as well as the transitioning pathways from the former towards the latter. This means that the directionality of the pathways can be both backwards, sideways and forwards, in a chemotaxis-like manner. This is also referred to as random walking with coherence [77] and is always away from certain undesirable sources (states) and towards some more desirable sources (states).

3. Methodological Agility

3.1. Avoiding the Danger of Path-Dependency

The benefit of visualizing the different sustainability transitions mentioned above, each with their own internal transitioning logics and dynamics embedded in radically different kinds of contexts – is that it rules out the possibility
of falling into the said trap of path-dependency [2, 29, 43], [74]. Path dependency is viewed as approaching and treating all sustainability transitions encountered in exactly the same manner by adopting the very same transitioning strategies for them, irrespective of their contextual differences. One way of avoiding this trap is by adopting methodological agility (MA), which was purposely developed as a meta-level research strategy [94] for knowing when and how to switch between mono-, multi-, inter-, and trans-disciplinary methodologies. In short, becoming methodologically agile can serve as an effective antidote for one-size-fits-all methodological panaceas contributing to discussed path-dependencies. Since MA always involves methodological decision-making, in one form or another, there is a need for using some relevant decision-making frameworks. The following methodological decision-making framework, adapted from the multi-ontology Cynefin framework [76, 80, 81], is presented here as a heuristic tool for figuring when and how to switch between (inter) and within (intra) the mono-, multi-, inter- and trans-disciplinary methodologies, each with their own relevant research methods:

![The arrow signifies the adopting and adapting of the Cynefin framework for the purposes of situating / contextualising mono-, multi-, inter- and trans-disciplinarity as four equally valid domain-relevant research methodologies. Source: [94].](image)

Note: the chaotic domain (depicted in the bottom left-hand corner of the above quadrants) has deliberately not been referred to in the discussion, simply because it signifies working with fundamentally random / ad hoc transitioning events with no discernable patterns. The latter are basically non-researchable, but rather warranting some or other immediate action (AKA “firefighting”). This contrasts with the other three domains which are all dealing with knowable / researchable sustainability transitions.

Avoiding the trap of path-dependency is, however, only one side of the proverbial coin when working on sustainability transitions in TTDR processes. The other side of the coin is almost the direct opposite, namely, that anything goes. Facing the complexity of complex sustainable transitions can quite easily be construed as making things overly complex to deal with and, therefore, trying to work with research methods, any methods per se is considered as a futile exercise, which can lead to some strong anti-methods ideas, practices and attitudes such as anything goes [21].

3.2. Using Abductive Reasoning Together with Ensemble Probabilistic Thinking

There are no compelling reasons for throwing the proverbial baby (read: methods) out with the bathwater. From the perspective of MA, a more constructive response would be learning how to use the logic of abductive reasoning [53-55, 63, 86, 87] in conjunction with, for example, ensemble probabilistic thinking v [62]. When taken together, it becomes possible, – at both the theoretical and practical levels, to abductively explore the directionality of the ‘best possible’ transitional route(s) to take in search of becoming more sustainable than the unsustainable / undesirable current situation, expecting some or other a priori certainties / guarantees in this regard. Therefore, at the more practical level, MA means developing some agile research methods by co-constructing dynamic thick / deep maps during the research process viii, that are necessary for guiding the directionality of unfolding real-life transitioning processes.

4. Reflections on Transformative Transdisciplinarity

4.1. From Transdisciplinarity (TD) to Transformative Transdisciplinarity (TTDR)

Transdisciplinarity (TD) is, broadly speaking, an appropriate methodological approach for tackling societal challenges which are simply too complex for tackling from within academia only and therefore warranting some or other societal stakeholder engagement in TD processes [94]. In short: TD is an appropriate research methodology for doing science with society when facing complex sustainability transitions in the polycrisis.

Figure 5 below provides a useful framework for visualising science and society coming together in
transdisciplinary research (TDR) processes when tackling the matters of concern [51, 56] facing them:

![Diagram of TDR processes]

Source: [42].

**Figure 5.** Signifying Collaborative Science and Society Transdisciplinary Processes.

However, TD is not intrinsically transformative and merely engaging with social actors does not in and of itself make the processes transformative. In order to be/come transformative, TD research processes must have some explicit knowledge and human interests [34], at both the practical and theoretical levels in order to change (Verändern) the complex transitioning challenges at hand, and not merely understanding (Verstehen) and explaining (Erklärung) them. “Philosophers have only interpreted the world in various ways; the point, however, is to change it” ~ Nieth Thesi on Feuerbach.

Engagement with and resolution of the practical dynamics of social change processes are by definition complex undertakings, since it involves the transformation of experience by combining extant and new social connections with empowerment via different forms of institutional experimentation [92]. This means, inter alia, forging the institutional arrangements (AKA institution-making or -building) necessary for social collaboration between various individuals and/or social groups for dealing with the challenges facing them [32, 33, 39]. This often requires can lead to the co-constructing of thick / deep maps during intentionally designed TTDR processes; which will be explained in more detail in Sections 4 and 5 below.

### 4.2. The Transformative Implications of Equiprobable Future States

Dealing with stated ill-defined / unknown future states in complex sustainability transitions has some far-reaching methodological implications for the transformative praxis of doing TTDR, because it is impossible to know or predict in advance which of the ill-defined / unknown future states will actually be more sustainable than the current unsustainable state. It is therefore better to approach them all with an equal chance of becoming more sustainable than the current undesirable state – in short, approaching them as equiprobable future states. This, in turn, means that their transitioning pathways can also not be known or predicted in advance, and that a more appropriate approach would, as alluded to earlier, be that of using abductive reasoning [53, 54, 55, 63, 86, 87] in conjunction with ensemble probabilistic thinking [62] for abductively exploring the directionality of the ‘best possible’ transitional route(s) to pursue in search of becoming more sustainable than the unsustainable / undesirable current situation.

However, the institutional arrangements needed for dealing with equiprobable future states implies working with something which may not necessarily already exist and, therefore, and which, must therefore, still be constructed afresh as social imaginaries – i.e. “the creative and symbolic dimension of the social world, the dimension through which human beings create their ways of living together and their ways of representing their collective life.” [88]. In the words of Bruno Latour this always involves a process reassembling the social, in which one has “to follow the actors themselves’, that is try to catch up with their often wild innovations in order to learn from them what the collective existence has become in their hands, which methods they have elaborated
to make it fit together, which accounts could best define the new associations that they have been forced to establish. If the sociology of the social works fine with what has been already assembled, it does not work so well to collect anew the participants in what is not—not yet—a sort of social realm” [50] and “The presence of the social has to be demonstrated each time anew; it can never be simply postulated. If it has no vehicle to travel, it won’t move an inch, it will leave no trace, it won’t be recorded in any sort of document. [50].

This Latourian notion of reassembling the social is quite an important one for understanding the double-challenge facing us in sustainability transitions, namely of deconstructing existing institutional arrangements, responsible for the unsustainable current situation, on the one hand, and reconstructing different ones, contributing to more sustainable situations, on the other hand. Given the non-linearity of complex sustainability transitions, this means that the process of reassembling the social and institutional arrangements, necessary for ushering in more sustainable situations, needs to happen anew—as if for the first time. If the latter are ill-defined/unknown in complex situations, this, in turn, means that none of the imaginary sustainable futures, developed by the participants in TTDR processes, can be given some or other a priori preference above any of the others. An appropriate point of departure in this regard would be to approach these as said equiprobable sustainable futures—all with an equal chance, in principle, of becoming more sustainable than the current unsustainable state.

4.3. Formative Contexts

At the practical level, though, this always needs to be considered in terms of the specific contextual conditions within which said complex sustainability transitions are embedded. In other words, not only does the context matter, but that it matters significantly because context is never just some or other (static) background12 for explaining the meaning of social actors’ actions but rather a dynamic space in which interactions take place. Therefore, a more dynamic notion of context is instead needed here, one which accommodates the dynamism of interactions. The construct of formative contexts—which, in one way or another, are affecting and being affected by the actions of the social actors concerned [11, 14, 47, 89, 90, 91] is considered to be better suited.

For our purposes, and of particular interest here is the question of how the collaborative research activities involved in the co-constructing of thick/deep maps13 in TTDR processes can contribute to transformative institution-making processes by nudging [1, 79, 84] the different equiprobable sustainable futures in the direction of becoming more sustainable than the current unsustainable situation.

5. Reflections on Thick / Deep Mapping

5.1. The Map–Territory Relationship

An immediate question when engaging in the process of map-making is, what exactly are we producing when constructing maps? A good starting point to answering this question is to acknowledge that maps are signifiers of something(s), the signified, other than themselves, normally some or other road/pathway from point A to B. Taking this semiotic approach to maps avoids committing some category errors [72] of mistaking maps for the territory [48]. Yet, on the other hand, it allows for constructing something ‘real’ other than themselves, such as roads/pathways for how to get from point A to B, without the intention of wanting to (re)produce direct/exact mirror images [71] of said roads/pathways. This always warrants or requires some or other form of interpretation, which is at the core of the ideas developed in the relational semiology/semiotics of CS Peirce [64-66]. The latter idea developed by Pierce [64], with its triadic set of relationships—between signifiers, signified and interpreters, was adopted for our purposes of co-constructing dynamic thick/deep maps, is graphically depicted below:

![Figure 6. Signifying Triadic Semiotic Relationships.](image)

However, these rather abstract considerations of the map–territory relationship changes fundamentally when we find ourselves in different contexts, especially unknown territories when like when lost on a mountain during some inclement weather conditions. Under such different conditions, it is essential to have access to good/well-constructed maps [49] to help us find our way out of what could be serious life-threatening situations.

In other words, the question of what maps ‘are’ cannot be answered purely in the abstract, but should rather be answered in relation to the context and for which purpose(s) they are being constructed. As already alluded to for our purposes of doing TTDR, the intentional collaborative methodological endeavours of co-constructing of thick/deep maps are fundamentally interested not only in the understanding (Verstehen) and explaining (Erklärung) the complexity of sustainability transitions, but also in changing (Verändern) them. This, as indicated earlier, can be explored via a double-movement [69] type process of (simultaneously) deconstructing and reconstructing/reassembling the social-institutional arrangements necessary for ushering in some
sustainable futures that are more sustainable than the current unsustainable situation.

5.2. Theories / Praxes of Change

Engaging with the directionality of these change processes becomes particularly important when embarking upon said social-institutional building processes. This requires knowing and discerning both the speed, direction and effort involved in such processes, considering the many probable different directions in which this may develop. In short, what is warranted here is a praxis of change capable of nudging said the already mentioned equiprobable futures in more sustainable direction(s). As mentioned above, TD is not transformative per se and in order to become transformative it needs to have some expressed human and knowledge interests in bringing about social change.

There are indeed many kinds of theories / praxes of change available to choose from which are always context-specific, and dependent on the specific conditions and issues at hand. When working in the context of an informal settlement known as “Enkanini” in South Africa (2011-2016) for example, the praxis of change known as radical incrementalism was found to be an appropriate approach since it allowed for exploring small-scale social-technical changes with some shack dwellers in their informal social networks in Enkanini. However, as mentioned, radical incrementalism is only one of many theories of change and participants of TTDR processes would need to decide for themselves which of these theories of change would be best suited to the contextual conditions and issues they face.

In the Anthropocene era, it is critically important to be able to engage at the global level with both the means and effects of the anthropogenic changes made to some of the earth systems that we face today, such as climate change and its consequences). This has far-reaching implications for the process of co-constructing the what and how of thick / deep maps which should not be restricted to reassembling social-institutional arrangements between humans only, but also include non-human beings and structures such as insects, animals, trees, plants, water, soil, air etc. as part of wider ecological systems. In short, what is needed are thick / deep maps capable of working with certain technologies in social-technical systems (STS) as well as the fauna and flora in social-ecological systems (SES).

5.3. From Thick to Deep Maps: The Ontological Move

In order to do this, it is key to make an important ontological move by giving equal ontological status to both human and non-human actors such as trees, plants, water, soil etc. as being on par with human voices and methodologically speaking, it means adopting trans-disciplinary approaches in which the ‘trans’ in trans-disciplinarity signifies going beyond said two-world theory by developing and using practical level methods, such as co-constructing dynamic thick / deep maps, capable of generating / capturing quantitative and qualitative data across the natural versus the social divide.

Being involved in co-constructing dynamic thick / deep maps should, therefore, not be seen merely as an instrumental exercise in producing practical research methods. On the contrary, when performing said ontological move a more profound shift from thick to deep maps takes place which, as alluded to, means seeing and working with non-human voices as narratives on par with human narratives. Although human and non-human narratives are expressed / communicated in very different kinds of language, the process of working with narratives enables hermeneutic engagement with the meaning of said human–nonhuman interactions. Doing so is particularly important when facing the challenge of reassembling the social-institutional arrangements necessary for ushering in more sustainable futures. In other words, narrative sense-making is integral to co-constructing thick / deep maps, an exercise which should not be approached as being ‘context-free’, as it were, but rather taking place within the formative contexts of having to figure out which of the said equiprobable sustainable futures have the ‘best possible chance’ of becoming more sustainable than the current unsustainable situation.

In literature, the notion of ‘deep maps’ is predominantly associated with the building of spatial – three-dimensional maps. However, from the perspective of narrative action research (NAR) the notion of deep maps needs to be extended beyond mere physical spatiality – thereby deepening our understanding of the rich human–nonhuman interactions embedded within and enabled by said spatial settings. Key in this regard, though, is seeing and responding to non-human things / entities as narrating their ‘stories’ in their own non-human ‘language’ which, in turn, needs to be translated into natural / everyday language fit for human sense-making purposes. We need to ensure that it is at the deeper level that we start ‘seeing’ and ‘hearing’ trees, plants, soil, water etc. telling their ‘stories’ in the form of sounds (biophony), smells (olfaction), perceptions (observations) etc. However, making sense of all these different social-ecological interactions does not stop at merely understanding the meaning of things, at the deeper level of figuring out the best possible sustainability transitioning pathways, it also involves the double challenge of decision-making and action-taking. In other words, we need to know how to act appropriately in view of our sense-making of the complexities facing us.

5.4. Unequal Knowledge / Power Relationships

The co-constructing of thick / deep maps never takes place in equal knowledge / power relations in which academic experts and societal stakeholders meet each other on equal

6.1. Faceting the Case: Layered Thick / Deep Maps

When dealing with complex sustainability transitions, the process of institution-making is a multi-faceted undertaking, involving the (re)assembling of institutional arrangements around many different social and environmental issues. In short, dealing with the complexity of (re)assembling social-ecological systems (SES) pose some interesting challenges for visualising thick / deep maps appropriately. One way of doing this is by ‘faceting the case’ [73, 82] – which can be presented as layered thick / deep maps – as per example below. Doing it this way also makes it easier to avoid falling into the trap of conflating the map–territory relationship, as alluded to above, simply because it is impossible to find such layered territories in reality – and, therefore, compels us to focus our attention on the co-production of some well-constructed maps, as heuristics for decision-making and action-taking, rather than trying to produce models of the structure of reality itself.

Since it is not possible – theoretically and practically speaking – to deal with the full complexity of real-life sustainability transitions, faceting the case should not be seen as an exercise in reductionism, but rather as a useful way of figuring out what are the key aspects that should be in/excluded for co-constructing the layered thick / deep maps. When visualising thick / deep maps in their multi-layered arrangements, it is important to do this in a manner making it possible to represent the many different horizontal and vertical connections within and between the layered facets / aspects – as per the example below:


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Figure 7. Signifying Layered Thick Maps.
6.2. Mapping Tools

There are indeed many different tools for constructing and visualizing dynamic thick / deep maps – with only some examples displayed in the table below:

<table>
<thead>
<tr>
<th>Tools</th>
<th>URLs</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agent-based Modeling (ABM)</td>
<td><a href="https://www.youtube.com/watch?v=j8FhiM2zPzw">https://www.youtube.com/watch?v=j8FhiM2zPzw</a></td>
<td>ABM is an important tool for co-constructing thick / deep mapping – especially if we see ‘agents’ as both human and nonhuman actors with equal ontological status shaping and being shaped by their mutual / two-way interactions in SES (as per Latourian actor network theory - ANT) (Latour, 2007).</td>
</tr>
<tr>
<td>Boids</td>
<td><a href="https://en.wikipedia.org/wiki/Boids">https://en.wikipedia.org/wiki/Boids</a></td>
<td>Boids is an artificial life program, developed by Craig Reynolds in 1986, which simulates the flocking behaviour of birds. &quot;Boid&quot; corresponds to a shortened version of &quot;bird-oid object&quot;, which refers to a bird-like object with emergent behavior; that is, the complexity of Boids arises from the interactions of individual agents (the boids) adhering to a set of simple rules namely: separation: steer to avoid crowding local flock-mates alignment: steer towards the average heading of local flock-mates cohesion: steer to move towards the average position (center of mass) of local flock-mates Adopting these ideas and principles are important for mapping social-ecological network-like interactions.</td>
</tr>
<tr>
<td>Fitness Landscapes</td>
<td><a href="https://en.wikipedia.org/wiki/Fitness_landscape">https://en.wikipedia.org/wiki/Fitness_landscape</a></td>
<td>Fitness landscapes come out of evolutionary biology in the work of Stuart Kauffman (Kauffman, 1993) to visualize the relationship between genotypes and reproductive success. It is assumed that every genotype has a well-defined replication rate (often referred to as fitness). This fitness is the &quot;height&quot; of the landscape. Genotypes which are similar are said to be &quot;close&quot; to each other, while those that are very different are &quot;far&quot; from each other. The set of all possible genotypes, their degree of similarity, and their related fitness values is...</td>
</tr>
<tr>
<td>Static Flows</td>
<td><a href="https://www.youtube.com/watch?v=4pdiAneMMh">https://www.youtube.com/watch?v=4pdiAneMMh</a></td>
<td>This tool focuses more specifically on mapping different power relations in human networks – important for tracking &amp; visualizing the spatial / relational distribution of unequal knowledge/power relations.</td>
</tr>
<tr>
<td>Connected</td>
<td><a href="https://www.humannaturelab.net">https://www.humannaturelab.net</a></td>
<td>This tool is specifically used for tracking &amp; visualizing emerging human / social networks – and, therefore, needs to be used in combination with Internet of Nature (IoN) tools for tracking &amp; visualizing human and nonhuman interactions in SES – see below for some examples of IoN tools.</td>
</tr>
<tr>
<td>Net-Map</td>
<td><a href="https://netmap.wordpress.com/about/">https://netmap.wordpress.com/about/</a></td>
<td>This tool focuses more specifically on mapping different power relations in human networks – important for tracking &amp; visualizing the spatial / relational distribution of unequal knowledge/power relations.</td>
</tr>
</tbody>
</table>

Table 1. Table of Thick / Deep Mapping Tools.
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</thead>
<tbody>
<tr>
<td>Dynamic Flows:</td>
<td>[Image]</td>
<td>then called a fitness landscape. The idea of a fitness landscape is a metaphor to help explain flawed forms in evolution by natural selection, including exploits and glitches in animals like their reactions to supernormal stimuli &amp; adjacent possibles.</td>
</tr>
<tr>
<td>Narrative tools:</td>
<td>[Image]</td>
<td>Online narrative tools, such as a Sensemaker, helps to gain unique qualitative insights into the rich contextual dynamics in which the issues we are facing are embedded by identifying and illuminating narrative patterns for human sense-making purposes.</td>
</tr>
<tr>
<td>Sensemaker:</td>
<td>[Image]</td>
<td>Narrative landscapes can be used for capturing positive and negative lived experiences – signifying attractors as areas of attraction towards which social change actions can be nudged – AKA adjacent possibles – vs. repellants as those negative areas to move away from (avoidance) – signifying said double movement (Polanyi, 2001).</td>
</tr>
<tr>
<td>Dynamic narrative landscapes:</td>
<td>[Image]</td>
<td>Dynamic fitness / narrative landscapes taking the notion of fitness landscapes a step further with its dynamic visualization of the connections both within and between the layers / facets.</td>
</tr>
<tr>
<td>Deep Mapping:</td>
<td>[Image]</td>
<td>The notion of ‘deep maps’ means going beyond ‘thick maps’ in the sense that it is at the ‘deeper’ level where the ‘transformation’ from mere quantitative data to qualitative stories occurs – enabling sense-making and decision-making (without which this is very difficult, if not impossible) – this ‘transformation’ from data to stories happens by asking the meaning question: what does all numbers / stats etc. mean for us and how should we act appropriately in the situation at hand and from which this (embedded) data emerges? For this to happen, it is important to realize that what we are fundamentally interested in are signified human and nonhuman stories and for this to happen it is key to see / approach nonhuman things – trees, plants, soil, water, air etc. – as ‘telling’ / ‘expressing’ stories demanding signification on par with human stories – enjoying equal ontological / agency status as humans (Latour, 2007).</td>
</tr>
<tr>
<td>Internet of Nature (IoN):</td>
<td>[Image]</td>
<td>Using various IoN smart technologies is one way of working with natural nonhuman stories is. These can capture both quantitative and non-quantitative data of trees, plants, soil, water, air etc. An example of non-quantitative data are the sounds produced by trees and plants (biophony). Very importantly, both kinds of data</td>
</tr>
<tr>
<td>[7, 8, 9, 41, 60, 61, 70, 98]</td>
<td>[Image]</td>
<td></td>
</tr>
</tbody>
</table>
Tools | URLs | Comments
--- | --- | ---
Biophany: |  | need to be approached in the same way as qualitative data – i.e. interpreted as signs / signifiers signifying some-thing(s) other than the data or sounds themselves (Peirce, 1974; Peirce and Buchler, 1955; Peirce and Peirce, 1982) – in other words: communicating ‘meaning’, about the conditions of the environment / context in which they are embedded. This is indeed key for our fundamental interested in signified human and nonhuman stories and for this to happen it is key to interpret the quantitative ‘data’– produced by nonhuman things and captured / visualized by IoN tech – as ‘telling stories’ warranting signification on par with human stories. Doing so will hopefully be captivating / interesting to all the participating stakeholders in TTDR processes – natural scientists, social scientists and societal actors – because the ‘meaning’ of nonhuman stories are not always immediately clear, but can only be figured out collaboratively…
Dynamic dashboards: |  | Thick maps can be developed and visualized as dynamic dashboards – playing an important role in real-time sense-making and decision-making purposes in TTDR processes (ensuring the continuous flow of quant-qual data). In other words: co-constructing thick maps as dynamic dashboards become ‘texts’ for 2nd iteration of interpretation in Peircean triadic hermeneutic circle:

Source: Self-generated.

Note: The list of tools presented above is by no means intended to be an exhaustive list of all the tools available, but merely some examples of what can be used for constructing thick / deep maps. Readers are, therefore, invited to bring their own appropriate tools into the research process when engaging with co-constructing and visualizing their own thick / deep maps.

7. Conclusion

7.1. Thick vs Deep Maps

Not all sustainability transitions will necessarily involve co-constructing deep maps. The need for the latter arises more specifically when dealing with human–nonhuman interactions in SES between humans and trees, plants, soil, water, air etc. and/or within STS between humans and certain technologies – ranging from hard infrastructure to the internet of things smart technologies. Either way, what matters is performing the said ontological move of bestowing humans and non-humans with equal ontological status as network(ed) actors – which, for our purposes of doing TTDR, means using dynamic thick / deep maps as a way of expressing and communicating non-human narratives for human sense-making and decision-making purposes, when facing the challenge of reassembling social-institutional arrangements during complex sustainability transitioning processes.

7.2. Systems, Target, and Transformation Knowledge

As mentioned briefly, TTDR processes need to be guided by some appropriate theories / praxes of change – such as the example of radical incrementalism (RI) [36, 95] – experimented with in a specific informal settlement context in South Africa. Critically important in this is the double-role that the co-production of systems target, and transformation knowledge play in pursuing said theories / praxes of change, and, within this, the role that the co-construction of thick / deep maps can play in co-producing said systems, target, and transformation knowledge. This is indeed an unexplored area of research, which has not been explicitly addressed in this paper, but which will be further pursued in future TTDR.

7.3. Liminal Spaces / Liminality

In general, liminal spaces / liminality refers to certain boundary-crossing or threshold occurrences experienced as transitioning from a particular physical, existential, spiritual…
aesthetic etc. state to another. In short, in-between places and spaces when undergoing certain transitions. When imagining this passage from one state to another, it is important not conceive of liminal spaces as ‘empty’ space where nothing happens, but rather as something akin to the quantum vacuum, breaching with energy and sub-atomic particle interactions bursting in and out of existence, as it were.

For our purposes, liminal spaces / liminality refers to those interim reassembling of the social-institutional arrangements necessary for making the transitioning between certain unsustainable (current) and more sustainable (future; not yet existing) states. Although of an interim nature, the social-institutional arrangements made in / during these liminal spaces may very well be adopted and become what is agreed as being more sustainable situations than the current unsustainable situation. Of particular importance in this, is the role that the co-construction of dynamic thick / deep maps can play in affecting the directionality of sustainability transitions in these liminal social-institutional spaces via said real-time visualizing / feedbacking of the transitioning experiences – which, in turn, will be different in said linear vs non-linear transitions. However, this is another unexplored area of research, not specifically addressed in this paper, but which will be further pursued in future TTDR.

7.4. The (Language) Performativity of Thick / Deep Maps

Co-constructing dynamic thick / deep maps also involves performative language games – bringing together some of the core ideas developed by J L Austin and L Wittgenstein [3, 97]. In other words, in the context of academic and societal stakeholder engagement in transdisciplinary research processes, looking at the possible social-institutional effects produced via performing dynamic thick / deep maps with its own internal set of ‘rules’ for this task at hand [12, 67]. Although critically important, this important aspect of co-constructing thick / deep maps falls outside the parameters of this paper and is, therefore, also considered of sufficient importance for more in-depth systematic exploration in future.

References


project-based disciplinary experts are still working separately on sustainability transitions – as in mono-disciplinarity – but with the difference that their single disciplines are theorizing the sustainability transitions facing them within the logic, ideas, concepts, principles, methods etc. of their own base disciplines, but still without the need for collaborating with any other disciplines and/or societal stakeholders.

4 Multi-disciplinarity is defined and understood as the research practice in which project-based disciplinary experts are still working separately on sustainability transitions – as in mono-disciplinarity – but with the difference that their individual efforts are being integrated by the project leader – normally towards the end of the project. In inter-disciplinarity, though, the disciplinary experts start seeing the need for some or other collaboration by borrowing some ideas, concepts, practices etc. from other relevant disciplines to better understand the sustainability transitions at hand in terms of their own base disciplines, but still without the need for engaging with any societal stakeholders, simply because the knowledge generated during such inter-disciplinary collaborations is considered sufficient for tackling the complicated sustainability transitions at hand.
research process) by walking [40].

9 Philosophically speaking, this means moving from the phenomenology of lived experience to institution-making and -building.

10 Which, for the purposes of this paper, will hereafter be referred to more specifically as (complex) sustainability transitions. "The reflection and action directed at the structures to be transformed" [24]. For our purposes this means reflection and action directed at the, alluded to, double-challenge of deconstructing certain undesirable institutional arrangements, responsible for the unsustainable current state, on the one hand, and reconstructing or replacing them with more desirable institutional arrangements, necessary for ushering in some more sustainable futures, on the other hand. Like a stage in a theatre production, where the actors only interact with each other, but never with the stage or the stage with the actors.

11 In other words: assembling the ‘vehicles’ with which to transport / convey things as mentioned by Bruno Latour above.

12 See above reference to non-linear chemotaxis like movements in complex situations.

13 The notion of praxis of change is used here deliberately rather than that the more familiar theory of change, since praxis is used here in the double Freirean sense of the word: practice-informed theory and theory-informed practice [24, [25, [40].

14 This means working with changes that were sufficiently ‘small’ to apply the principle of: amplifying (up- and cross-scaling) what works and damping (stopping or redirecting) what does not work [75, 78].

15 As mentioned, technologies ranging from hard infrastructure (below) the ground to internet of objects or internet of nature devices providing real-time monitoring feedback and information on whatever non/human things are being tracked and traced.

16 It is worthwhile noting the title of Descartes famous book on the "Discourse on Method" – referring to Method as a way of mathematical reasoning applied to all fields of inquiry.

17 Explained in more detail below.

18 As per ensemble forecasting thinking / reasoning.

19 As per, for example. the double helix DNA model in Biology [96].

20 As per ensemble forecasting thinking / reasoning.

21 As per, for example. the double helix DNA model in Biology [96].

22 Our understanding of the world and how to act appropriately in the world relates to Kant’s three fundamental questions: What Can I Know? What Should I Do? What May I Hope? [44, 45, 46].

23 As per ensemble forecasting thinking / reasoning.

24 This does not mean permanently in/excluding the burning issues from the layered thick / deep maps. Another way to approach this would be via the dynamic ‘foregrounding / backgrounding’ dynamic [52]. In other words, the issues that are being foregrounded for co-constructing thick / deep maps may very well, at a later stage, be shifted into the background – and vice versa – depending on the stakeholders’ changing insights and understandings of their context.

25 Epistemologically speaking, three different kinds of knowledge with systems knowledge referring to descriptive knowledge of what ‘is’; target knowledge referring to normative knowledge of what ‘ought to be’; and transformation knowledge to strategic knowledge of how to transition from what ‘is’ to what ought to be [35, 69].

26 See: https://en.wikipedia.org/wiki/Liminality

27 See: https://en.wikipedia.org/wiki/Vacuum_energy