

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

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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 Synergic 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.

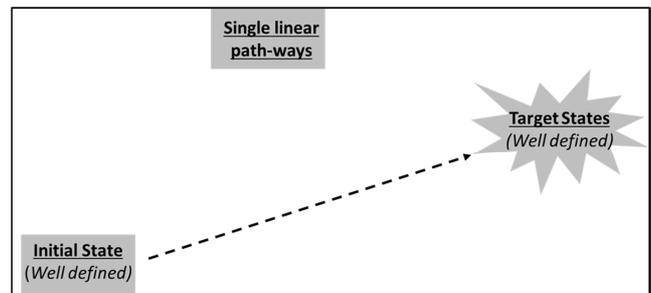
2. Contextually Different Sustainability Transitions

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:



Source: Self-generated.

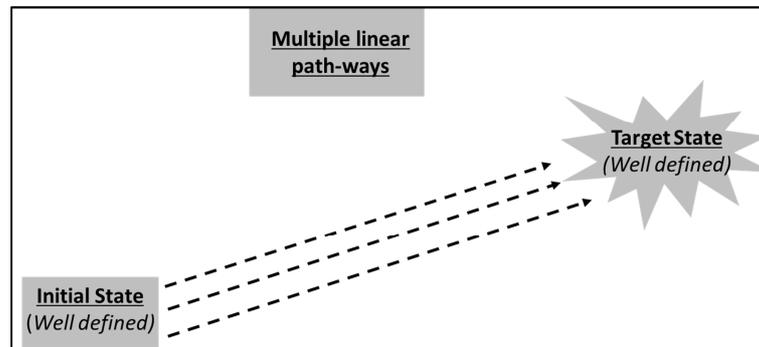
Figure 1. Signifying single linear, straightforward transitioning pathways.

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

practices³ 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:



Source: Self-generated.

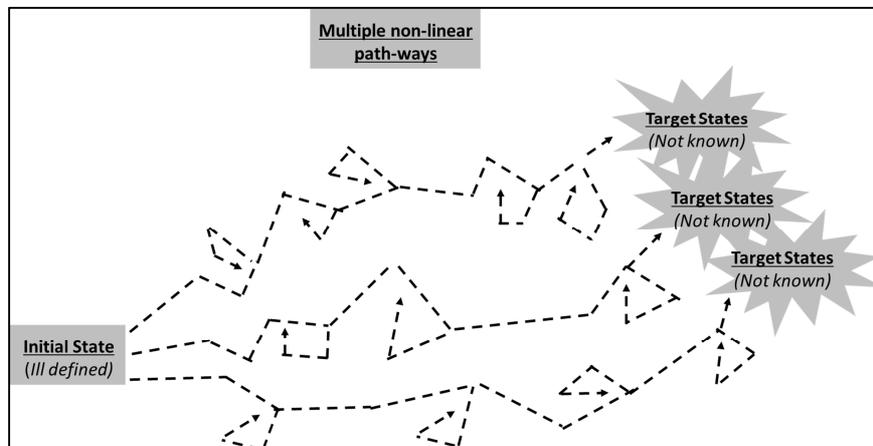
Figure 2. Signifying multiple linear, straightforward transitioning pathways.

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 interdisciplinary approaches⁴ for determining which of the multiple (linear) transitioning pathways should be pursued in certain cases, multiple pathways in parallel.

2.3. Complex Transitions

Are characterized by multiple, non-linear transitioning pathways:



Self-generated.

Figure 3. Signifying multiple non-linear transitioning pathways.

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 approaches⁵. 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 manner⁶. 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, *be/coming 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:

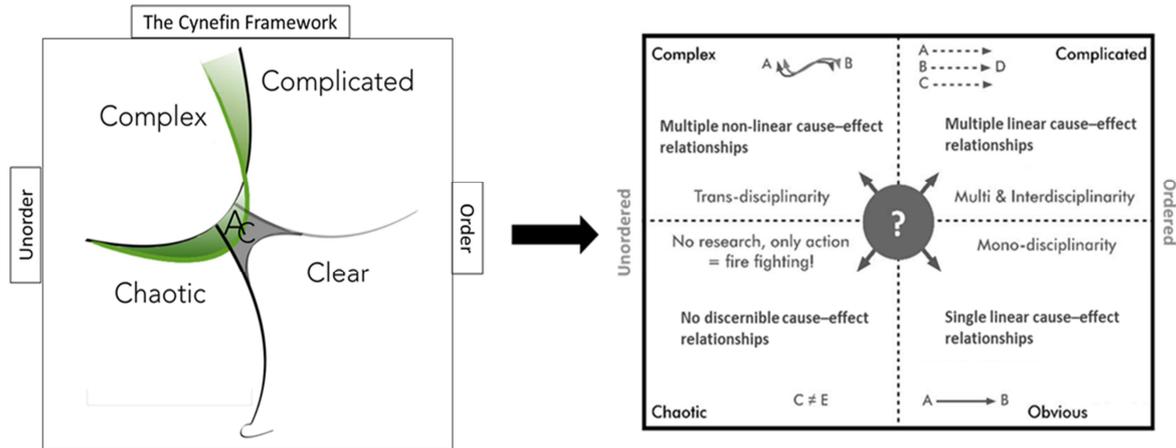


Figure 4. The arrow signifies the adopting and adapting of the Cynefin framework for the purposes of situating / contextualising mono-, multi-, inter- and trans-disciplinarity as four equally valid domain-relevant research methodologies. Source: [94].

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*^{vii} [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.

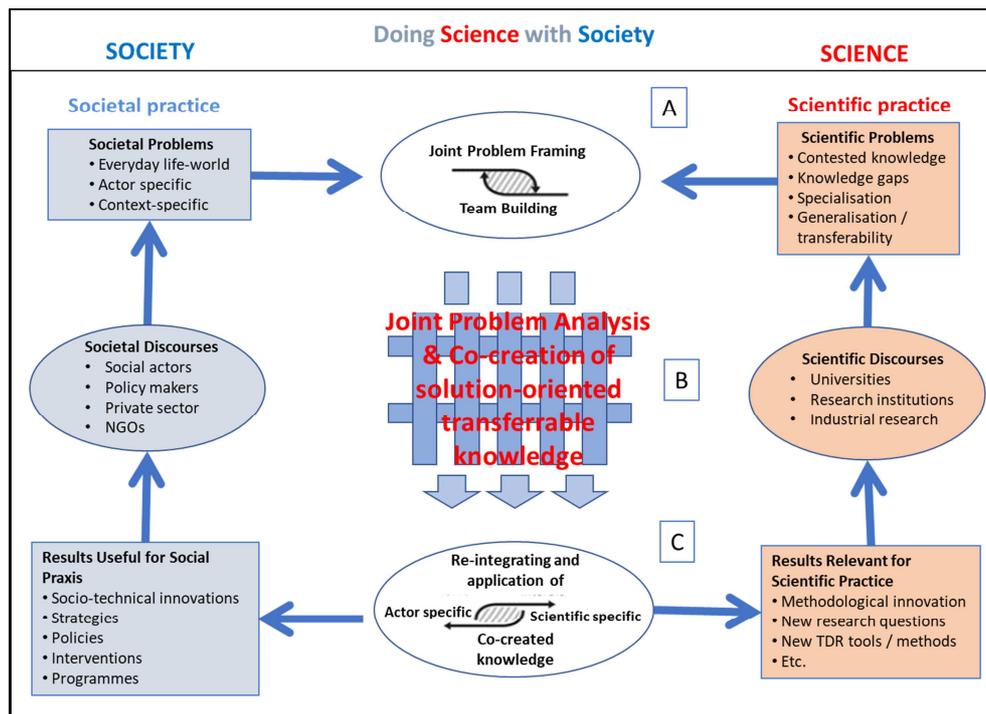
4. Reflections on Transformative Transdisciplinarity

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:



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” ~ 11th Thesis 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 experience⁹ 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 challenges¹⁰ 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 praxis¹¹ 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, [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.

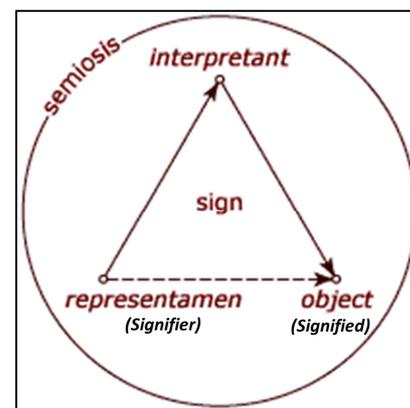
For our purposes, and of particular interest here is the question of how the collaborative research activities involved in the co-constructing of thick / deep maps¹³ in TTDR processes can contribute to transformative institution-making processes by *nudging* [1, 79, 84] the different equiprobable sustainable 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 Peirce [64], with its triadic set of relationships – between *signifiers*, *signified* and *interpretants*, was adopted for our purposes of co-constructing dynamic thick / deep maps, is graphically depicted below:



Source: [64].

Figure 6. Signifying Triadic Semiotic Relationships.

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 directions¹⁴ in which this may develop. In short, what is warranted here is a *praxis of change*¹⁵ 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 [34] 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* [36, 85, 95] was found to be an appropriate approach since it allowed for exploring small-scale¹⁶ 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 technologies¹⁷ 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 [50] in their networked interactions with each other. Making this ontological move in effect means *overcoming* the Cartesian two-world theory of *res extensa* versus *res cogitans* as two fundamentally separate worlds or realities. Doing so has some far-reaching epistemological and methodological implications. Epistemologically speaking, it means extending the notion of ‘epistemic justice’ [28] to include the ‘voices’ of 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 theory¹⁸ 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 language¹⁹, 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’²⁰ 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 [7, 8, 70]. However, from the perspective of narrative action research (NAR) [93], the notion of deep maps needs to be extended *beyond* mere physical spatiality – thereby deepening our understanding of the rich human–nonhuman interactions²¹ 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*²² 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

footing, even where and when this is intentionally posited as a goal for TDR processes [73]. Therefore, acknowledging from the onset that relevant stakeholders in TTDR processes participate in *unequal knowledge and power relations* means they will also contribute in *unequal* measures to the co-constructing of thick / deep maps – depending on their knowledge of the complexity of the issues at hand.

Key in doing this would be to look at *power* not necessarily as a ‘destructive’ force *only*, but rather as a ‘productive’ force, capable of actually *producing* certain kinds of knowledge – along the lines of some Foucauldian thinking on this [4, 5, 13, 16, 19, 20, 22, 23, 37]. Adopting this logic, in turn, makes it possible to conduct TTDR processes guided by the principle of *epistemic justice* [27, 28] with the view of using said the indicated asymmetric dynamics in *unequal knowledge/power relations* ‘productively’, – i.e. as a positive epistemological force for *co-producing* thick / deep maps.

Note: Dealing with the dynamics of unequal knowledge I power relations is also a means of addressing the political economy (PE) of decision-making in TTDR processes.: Do co-produced thick maps have the potential of influencing and being influenced by the competing / conflicting / contradictory needs and interests of participating social actors in TTDR processes? Will the co-production of thick maps in TTDR processes enable the participating decision-makers to better understand not only their own needs and interests (= positions), but also others' needs and interests? If so, how would this affect their own decision-making and participation in TTDR processes?

The implications of adopting this relational conception of knowledge / power relations are that we are dealing not with static but dynamic asymmetric knowledge I power relations. In practice, these can easily ‘criss-cross’ amongst the participating stakeholders – in accordance with the different / varying roles they play during the different phases of collaborative TTDR processes [95]. As mentioned, what is critically important in all of this, is not to see unequal knowledge/power relations as something which should be eliminated from TTDR processes, but rather as something which should be engaged with in a methodologically agile manner by *learning how to work with* the asymmetric dynamics when facilitating the co-constructing of thick / deep maps.

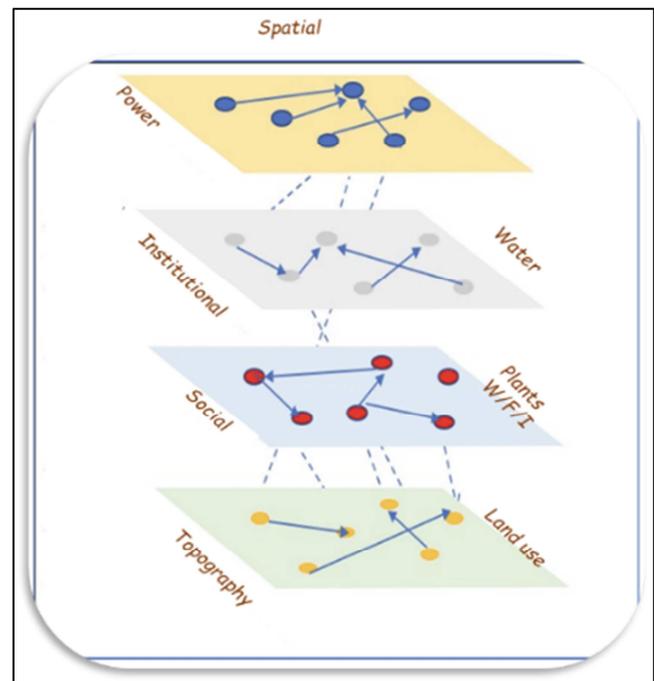
6. Visualizing Dynamic Thick / Deep Maps

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 itself²³.

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/excluded²⁴ 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:



Source: [31]

Figure 7. Signifying Layered Thick Maps.

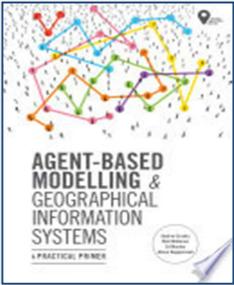
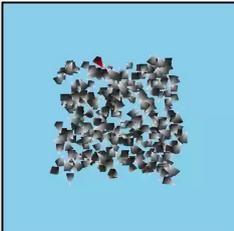
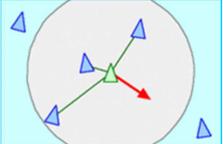
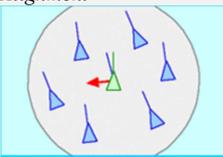
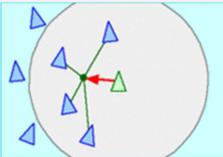
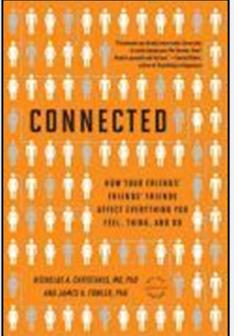
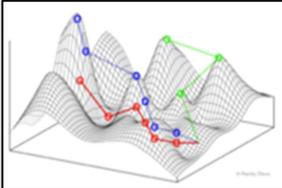
However, as mentioned above, it is critically important to be mindful of the fact that these multi-layered thick / deep maps are being co-produced in/by unequal knowledge/power relations – with the real possibility of domination by those with higher levels of education and ‘more’ knowledge, skills and resources. *Who* decides *which* faceted layers should be produced and *for whom* and *who* should be involved in integrating the different layers into some or other coherent representations of transitioning pathways are all important questions which needs to be carefully facilitated during TTDR processes, when focusing on the co-construction of said thick / deep maps.

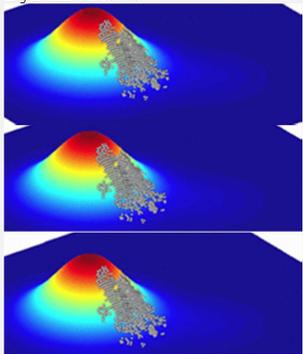
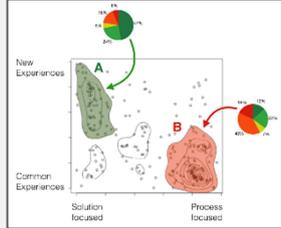
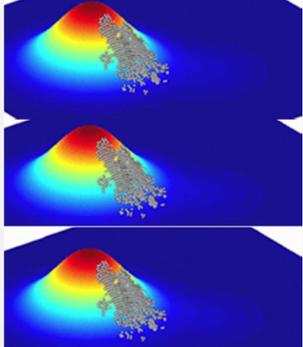
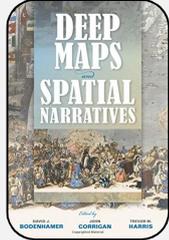
6.2. Mapping Tools

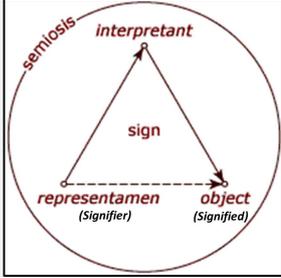
There are indeed many different tools for constructing and

visualizing dynamic thick / deep maps – with only some examples displayed in the table below:

Table 1. Table of Thick / Deep Mapping Tools.

Tools	URLs	Comments
<p>Agent-based Modeling (ABM):</p>  	<p>https://www.youtube.com/watch?v=j8FhiM2zPzw</p>	<p>ABM is an important tool for co-constructing thick / deep mapping – especially if we see ‘agents’ as both human and nonhuman actors with <i>equal ontological status shaping and being shaped</i> by their mutual / two-way interactions in SES (as per Latourian actor network theory - ANT) (Latour, 2007).</p>
<p>Boids:</p> 	<p>https://en.wikipedia.org/wiki/Boids</p> <p>Separation</p>  <p>Alignment</p>  <p>Cohesion</p> 	<p>Boids is an artificial life program, developed by Craig Reynolds in 1986, which simulates the flocking behaviour of birds. "Boid" corresponds to a shortened version of "bird-oid object", which refers to a bird-like object with <i>emergent behavior</i>; that is, the complexity of Boids arises from the interactions of individual agents (the boids) adhering to a set of simple rules namely: <i>separation</i>: steer to avoid crowding local flock-mates <i>alignment</i>: steer towards the average heading of local flock-mates <i>cohesion</i>: 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.</p>
	<p>https://www.humannaturelab.net https://breadboard.yale.edu</p>	<p>This tool is specifically used for tracking & visualizing emerging human / social networks – and, therefore, needs to be used in combination with Internet of Nature (IoN) tools for tracking & visualizing human and nonhuman interactions in SES – see below for some examples of IoN tools.</p>
<p>Net - Map toolbox</p> <p>Influence Mapping of Social Networks®</p>	<p>https://netmap.wordpress.com/about/</p>	<p>This tool focuses more specifically on mapping different power relations in human networks – important for tracking & visualizing the spatial / relational distribution of unequal knowledge/power relations.</p>
<p>Fitness Landscapes: Static Flows:</p> 	<p>https://en.wikipedia.org/wiki/Fitness_landscape https://www.youtube.com/watch?v=4pdiAneMMhU</p>	<p>Fitness landscapes come out of evolutionary biology in the work of Stuart Kaufmann (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 "height" of the landscape. Genotypes which are similar are said to be "close" to each other, while those that are very different are "far" from each other. The set of all possible genotypes, their degree of similarity, and their related fitness values is</p>

Tools	URLs	Comments
<p>Dynamic Flows:</p> 		<p>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 & adjacent possibles.</p>
<p>Narrative tools: Sensemaker:</p> 		<p>Online narrative tools, such 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.</p>
<p>Narrative landscapes:</p> 	<p>https://thecynefin.co/get-sensemaker/</p>	<p>Narrative landscapes can be used for capturing positive and negative lived experiences – signifying <i>attractors</i> as areas of attraction <i>towards</i> which social change actions can be nudged – AKA adjacent possibles – vs. repellants as those negative areas to move <i>away from</i> (avoidance) – signifying said double movement (Polanyi, 2001).</p>
<p>Dynamic narrative landscapes:</p> 	<p>https://www.youtube.com/watch?v=4pdiAneMMhU</p>	<p>Dynamic fitness / narrative landscapes taking the notion of fitness landscapes a step further with its dynamic visualization of the connections both <i>within</i> and <i>between</i> the layers / facets.</p>
<p>Deep Mapping:</p> 	<p>[7, 8, 9, 41, 60, 61, 70, 98]</p>	<p>The notion of ‘deep maps’ means going <i>beyond</i> ‘thick maps’ in the sense that it is at the ‘deeper’ level where the ‘transformation’ <i>from</i> mere quantitative data <i>to</i> qualitative stories occurs – enabling sense-making and decision-making (without which this is very difficult, if not impossible) – this ‘transformation’ <i>from</i> data <i>to</i> stories happens by asking the meaning question: <i>what</i> does all numbers / stats etc. mean for us and <i>how</i> should we act appropriately in the situation at hand and from which this (embedded) data emerges?</p>
<p>Spatial Agent-based Modelling and Simulations - A Review</p> <p>Technical Report CSTN-153</p> <p>A. V. Hosseini, K. A. Hawick Institute of Information & Mathematical Sciences Massey University at Albany, Auckland, New Zealand Email: {a.v.hosseini k.a.hawick}@massey.ac.nz</p> <p>October 7, 2014</p>		<p>For this to happen, it is important to realize that what we are fundamentally interested in are <i>signified</i> 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 <i>human</i> stories – enjoying equal ontological / agency status as humans (Latour, 2007).</p>
<p>Internet of Nature (IoN):</p> 	<p>http://internetofrees.tech https://www.itreetools.org/ https://www.treetracker.ai/ https://www.nsf.gov/discoveries/disc_summ.jsp?cntn_id=123046</p>	<p>Using various IoN smart technologies is <i>one way</i> 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</p>

Tools	URLs	Comments
 <p>Internet of Trees</p> <p>Biophany:</p>  <p>National Science Foundation WHERE DISCOVERIES BEGIN</p> <p>Studying Nature's Rhythms: Soundscape Scientists Spawn New Field</p> <p>Listen to biophony, geophony, anthrophony: The 'music' of Planet Earth</p> <p>Dynamic dashboards:</p>  <p>HOW TO CREATE THIS</p> <p>Pinexl Consult Travel Cost Dashboard</p> <p>DYNAMIC EXCEL DASHBOARD</p>		<p>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.</p> <p>This is indeed key for our fundamental interested in <i>signified</i> 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...</p> <p>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).</p> <p>In other words: co-constructing thick maps as dynamic dashboards become ‘texts’ for 2nd iteration of interpretation in Peircean triadic hermeneutic circle:</p> 

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*²⁵ 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, spiritual²⁶,

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 vacuum²⁷, 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.

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1 Highlighting their similarities and differences.

2 Signified by the dotted line in figure 3.

3 Mono-disciplinarity is defined and understood as the research practice in which disciplinary experts are theorizing the sustainability transitions facing them strictly *within* the logic, ideas, concepts, principles, methods etc. of their own single disciplines *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 are considered sufficient for tackling the *complicated* sustainability transitions at hand.

5 Discussed in more detail in Section 3 below.

6 See: <https://www.youtube.com/watch?v=GD0kXgYv2A>.

vii Explained in more detail in Section 3 below.

viii Or, metaphorically speaking, in the words of Freire: *making the road (read:*

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.

11 “*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.

12 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.

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

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

15 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].

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

17 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.

18 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.

19 Explained in more detail below.

20 As per ensemble forecasting thinking / reasoning.

21 As mentioned, *between* humans and trees, plants, soil, air, water etc.

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

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