Transformation happens in the unbelievable

Using participatory modelling to pave realistic paths towards idealistic futures

Sustainability transformation is necessary. Since "business as usual" is no longer an option, unbelievable future visions are needed to spark change and steer collective action. We discuss how modelling, with its scientific rigor, and inclusive participation, with its sensitivity to power dynamics, can be brought together to complement one another and make unbelievable future visions come true.

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Models: Science-based but not transformative?

Rapid system-level changes are urgently needed in response to the ongoing sustainability crisis. Sparking such deep, collective transformation is not easy, and controlling it may be even more challenging. Visions of the future are important drivers of change, and transformation happens in the unbelievable (Pereira 2022). Visions of (un)sustainability are often created with models, for example, climate or biodiversity scenarios. Models are exceptional tools for crystallizing scientific knowledge (Lee et al. 2018), and they should not be abandoned but rather used in new ways.

The power of models serving decision-making is built on their versatility. There is abundant scientific literature regarding the societal usefulness of models. Firstly, their ability to present comprehensive information is considered valuable (e.g., Lemos and Rood 2010, Brunet et al. 2018). Secondly, models are being constantly improved by managing and minimizing their uncertainties (e.g., Crossman et al. 2013). And thirdly, there are various examples of successful knowledge transfer through models (e.g., Saltelli et al. 2020).

There is a great variety of models. Complex equilibrium models are used to describe the economic impacts of climate change, while maps can be used to depict the availability and accessibility of ecosystem services in changing climate conditions. Models can reflect biophysical systems, societies, or their interlinkages. Some models are geographically narrow while others contain the whole Earth. In this text we focus on models that study the relationship between human and non-human systems – for example, the consumption of natural resources and its impact on climate change or the state of local biodiversity.

Models hold significant epistemic power that can be harnessed to motivate or even steer sustainability transformation. While the modelled scenarios are informative, critique of modelling focuses especially on uncertainty, objectivity, and bias. Modellers must make conscious choices, for example, regarding what is excluded or included in the model (Lemos and Rood 2010). The importance of these choices should not be underestimated since they cast a long shadow while adding an essential subjective element in the seemingly objective models. Less attention is paid to the system-level biases resulting from practices and trends within science or society. Models tend to recreate and reinforce the rules of the current system rather than changing it (see Fazey et al. 2020).

Instead of projecting accurate pathways to doom, we argue that models should be used to encourage transformation by paving the way towards desirable, unbelievable futures. Radical transformation requires our societies and knowledge systems to undergo deep restructuring. Predicting its outcomes with the rules of the current system is counterproductive. In this paper we discuss how models and participation may bring together the global and the local, the present and the future, the possible and the unbelievable, to further sustainability transformation.

Believable future visions steering current action

We can enable transformation by questioning worldviews and ways of sense-making – things typically taken for granted. Such elements can be analyzed from a systemic perspective by exploring *sociotechnical imaginaries (STIs)*, that means, co-produced, collectively held and institutionally stabilized visions of the futures where scientific and technological advances may lead (Jasanoff and Kim 2009, p. 120). STIs outline why some futures are >

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considered feasible while others are deemed impossible or radical. Here we propose considering models and the scenarios they produce as STIs in order to examine worldviews, structures and power dynamics that have thus far been overlooked in modelling.

STIs become institutionalized when a relevant organization, such as a public governance agency, enacts the STI and prioritizes it over competing visions (Jasanoff and Simmet 2021). One example of a shared imaginary reinforced by the rules of current systems is what we consider a necessity for a "good life", for example, high consumption levels of material and energy that our current industrial economic order depends on (Jasanoff and Simmet 2021). Similarly, models may portray never-ending economic growth and hence reinforce and renew STIs. Exposing such assumptions is the first step towards sustainability transformation.

Like visions and scenarios, STIs hold great epistemic power and are therefore important for sustainability transformations since they can either maintain status quo or challenge it. Language and agenda setting shed light on institutionalized STIs. For example, climate models have enabled "carbon neutrality" to become a powerful political goal (Jasanoff and Simmet 2021), while no net loss or nature positive goals are emerging for biodiversity. Another approach, especially used by the *UN Conventions,* is to define numeric goals, such as limiting global temperature rise to 1.5 degrees *(Paris Climate Agreement)* or protecting 30 % of land and sea areas globally by 2030 *(Kunming-Montréal Global Biodiversity Framework)*. Such goals are formulated with long negotiations and policymaking processes as well as scientific knowledge, including modelling.

While having clear, well-defined, and globally shared goals is undoubtedly important, these goals tend to draw an unnecessarily simple picture of the solution. For example, carbon neutrality goals tend to focus on creating pressure for technological development of renewable or nuclear energy instead of critically examining the need for energy consumption or the lock-ins created by technological developments. McLaren and Markusson (2020) indicate that when modelling simultaneously takes part in both setting the policy goals and drafting the technological developments needed to meet them, social and political transformation is continuously avoided. Due to the historical dominance of natural science and economics in modelling, society and its change have not been examined in the same level of detail (Köhler et al. 2018, Pohlmann et al. 2021). We propose rethinking the role of modelling and participatory approaches in planning, goal setting and implementation to ensure that societal change is addressed.

Harnessing the epistemic power of models with participation

As explained in the previous chapter, existing power dynamics have been reinforced rather than challenged, for example, by applying modelling to shaping policy agendas. That is where participation can come in.

Typically, participatory approaches are used to improve the accuracy and applicability of models (e. g., Brunet et al. 2018) and to ensure trust between model users and creators (Dilling and Lemos 2011) through participation of the key stakeholders.

Transition research views participation as an inclusive process that aims to broaden problem framing and actively address power dynamics throughout the knowledge production process (Pereira et al. 2018). Defining and framing a problem is an act of power in itself and inevitably marginalizes some while empowering others. Inclusive participatory approaches aim to bring together multiple ways of knowing, allowing a multitude of meanings and values to enter the discussion and finally tackling the vicious cycle of models recreating the same epistemic assumptions (Martin and Sanga 2023).

We urge modellers to view participation in this new light, not as an extra duty separate from core tasks of modelling but rather as an essential part which ensures the quality of the output. Participatory processes may not only improve problem framing and essentially the applicability of the model, but also introduce social and societal nuances into models (Burnett 2020).

A recent effort to renew the ways we produce, manage, and utilize scientific knowledge is the concept of a *transformative space,* that is, a participative environment encouraging new configurations of socio-ecological systems (Pereira et al. 2020) that can be used to introduce new viewpoints to familiar issues. By reframing shared imaginaries, new solutions and possibilities may become visible (see "structural approaches", Scoones et al. 2020). Another method integrating participatory methods and thinking about possible futures is participatory scenario planning (Hamann et al. 2022). Building on and going beyond such approaches, we see significant untapped transformative potential in combining modelling and participatory processes (see Haxeltine et al. 2017, Hukkinen et al. 2022). Participation may improve models by challenging existing problem framings and power dynamics, while models could ensure that future visions do not imply an overexploitation of the finite resources of the Earth.

Starting from the unbelievable, casting back to inform models

By not starting with modelling but with imagining, we can open up perspectives to desirable futures. Inclusive participatory processes can provide unbelievable future visions that challenge existing power dynamics and systems, while models could be used to explore whether and how systemic change can steer us towards these futures. Exploring unbelievable, yet possible trajectories by changing the rules can help us identify where the transformation potential of the current system lies, and point out the barriers to change.

Models excel in improving users' understanding of complex systems, by allowing the examination of a subsystem, for example, a single country or industry, and zooming out again to examine the interactions within the whole system. Portraying the

implications of proposed goals in various perspectives, sectors, countries, temporal and spatial scales contributes to a comprehensive overview of the system, thus increasing the understanding of whether and how the future visions could become a reality. Being able to test and to explore societal changes and their future impact makes sustainability transformation more tangible.

Unbelievable, idealistic visions of the future can, for example, be desirable results of strategic planning or participatory processes. At the same time, they may lack concrete details or fail in paying sufficient attention to trade-offs and lock-ins of current systems, for example, increased competition for land use due to simultaneous efforts to reach carbon neutrality and no net loss of biodiversity (Pörtner et al. 2021). The feasibility of these visions can be scrutinized by using scientific models to create presentations of land use options in our finite system (e. g., Forsius et al. 2023): What does meeting current quantitative climate and biodiversity goals mean for urban areas, agriculture, forestry and so forth? How would this impact citizens, their diets or consumption options? How would it impact the price of land and other natural resources? How would it impact the functions of society? Since sustainability transformation requires addressing complex, uncertain and massive systems, models can support the identification of impactful means of action, as well as portraying the scale of changes needed.

Potential pioneers for such use of models could be science panels both on international and national levels, or knowledge brokers involved in policy preparation, implementation, and spatial planning. For example, in strategic planning goals are often global or regional, but implementation happens on a local or national scale, and utilizing models in the process can ensure pursued impacts across spatial scales. Business and companies could also benefit from these approaches when projecting their future carbon or biodiversity footprints or handprints, or business turnover.

Conflicts and co-operation emerging with transformation

Modelling can provide the scientific base for future visions while participatory processes have the demanding task of tackling existing and emerging conflicts and creating co-operation. Sustainability goals are at times contradictory and prone to conflicts, and therefore adding a participatory element into the implementation process is crucial. Participation can help reconcile parties and create acceptance for the redistribution of harms and benefits. For example, transformative spaces can act as platforms to discuss inequality, responsibility, and roles within the transformation.

In addition to managing and preventing conflicts, participatory processes should aim to create new alliances. No one-size-fits-all blueprint for action exists, since "no single actor nor defined group can address and solve the problem alone; new alliances are required to radically transform the existing system" (Pereira et al. 2018). Broader participation strengthens agency and increases sustainability competences and capabilities to act, which in turn are important for ensuring long-term action and commitment to the cause (Scoones et al. 2020). This is especially important since it has been challenging to create sufficient action to meet the goals. Participatory approaches can ensure that models are embedded in the relevant social and societal conditions, and hence improve their performance and usability.

Participation may improve models by shaking up their problem framing and existing power dynamics, while the models could ensure that future visions can be met with the finite resources of the Earth.

Transforming the unbelievable into the possible

Visions of the future can steer collective actions and we consider significant, untapped potential in the co-operation of modellers and transition scholars. Combining modelling and inclusive participatory processes is not without its challenges, but it has great potential to drastically improve both, and to motivate sustainability transformation.

We conclude with three propositions:

1. ***Inclusive participation can improve problem framing and address power dynamics.*** Thus far, models have had the tendency to frame climate change or biodiversity loss from a technical point of view. Framing an issue and defining its context is an act of power, and to truly question the status quo, a more inclusive participation in problem framing and knowledge production is needed.
2. ***Models can visualise the impact of actions across temporal and spatial scales to portray the magnitude of changes needed.*** Models are invaluable tools to compare scales. By exploring models, it is possible to identify action with high transformational potential, and to substantiate the changes needed. This is especially important when preparing an implementation plan (see "systemic approaches", Scoones et al. 2020). Therefore, models could be used to navigate through transformations and improve our ability to steer them.
3. ***Pathways to unbelievable futures can be investigated with back-casting.*** To enable change, actors from individuals to states and industries need to envision futures that seem im- >

possible (Koning and van Dijk 2021). When back-casting is informed by participatory modelling, exploring agency through individual (e. g., establishing a meadow on one's yard), proxy (e. g., intensifying recycling at the workplace) and collective action (e. g., developing regulation to prevent nature loss) can ensure that all three are included in the implementation (Koskela and Paloniemi 2023).

Controlled sustainability transformation may be an illusion, but exploring unbelievable futures with modelling may help manage the uncertainty and complexity of the transformation. Together, inclusive participation and modelling can make the unbelievable possible.

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