CEST 2023

18th International Conference on Environmental Science and Technology

Athens, Greece, 30 August to 2 September 2023

Ethical considerations of participatory modelling in the context of sustainable development

AMOROCHO-DAZA H.[1,2,*], VAN DER ZAAG P.[1,2], SUŠNİK J.[1]

[1]Land and Water Management Department, IHE Delft Institute for Water Education, Delft, The Netherlands
[2]Water Management Department, Delft University of Technology, 2600 AA Delft, The Netherlands

*corresponding author:
e-mail: ham001@un-ihe.org

Abstract

Sustainable development deals with grand challenges related to human well-being and environmental sustainability. Assessing sustainability initiatives goes beyond technical solutions and requires the engagement and deliberation of multiple stakeholders. Participatory modelling is a promising approach to explore sustainability alternatives by using technical tools (e.g. simulation) while actively involving stakeholders. The discussion around sustainability alternatives has ethical implications as it deals with matters that affect people and the environment. However, despite ethical aspects are implicit in participatory modelling processes, they are often overlooked. This study aims to make visible the ethical dimension of participatory simulation models in the context of sustainability. Here we propose to have sustainable development and human rights as ethical standpoints for participatory modelling efforts in complex social-ecological settings. A practical-oriented ethical evaluation is proposed in the form of questions structured across a relevant participatory modelling framework. An ethical lens is essential to guide social-ecological systems modelling throughout to identify pathways that align with principles aiming to protect human dignity, promote justice, and prevent environmental harm. The proposed ethical framework aims to promote the design of socially accepted and ethically transparent models that support decision-making processes aligned with the Sustainable Development Goals (SDGs) transitions.

Keywords: ethics, participatory modelling, simulation, sustainable development, human rights

1. Introduction

1.1. Sustainable development and ethics

Sustainable development is a perspective that focuses on "meeting human needs of the current and future generations within the limits of the environment" (Wu, 2013). Thus, it focuses on complex challenges inherent to social-ecological systems (SES), such as scarce ecological resources, economic activities and societal responsiveness (Kirchschlaeger, 2021). The United Nations Sustainable Development Goals (SDGs) take place in this context aiming to promote a global transition towards a paradigm of sustainable development (UN General Assembly, 2015).

In dealing with such challenges, the sustainable development paradigm is not value-neutral. First, it relies on principles such as intra/intergenerational justice and the precautionary principle (Paterson, 2007; Spijkers, 2018). Therefore, designing sustainability policies requires open deliberation about these principles in order to operationalise them. Second, as humans are at the centre of sustainable development, human rights need to be considered in the context of sustainability (Kirchschlaeger, 2021). This is more evident now that the UN General Assembly (2022) recently recognised the human right to "a clean, healthy and sustainable environment", implying that every human being is a right holder, but also a duty-bearer towards a sustainable environment. Thus, an ethical lens is necessary to guide sustainability practice.

1.2. Simulation models and participatory approaches

The path towards sustainability requires comprehensive approaches supporting policy-making around SES. This process is challenging as it relies on multiple approaches and disciplines. In contrast, simplistic and short-term perspectives can lead to policy choices that are ineffective in reaching their intended objectives or may even have serious unintended consequences (Sterman, 2006). Policy resistance (i.e. systems resistance to policy interventions) comes from the human-bounded capacity to understand complex systems (Sterman, 2002). Likewise, poor knowledge of a system's main drivers may lead to unsatisfactory long-term policy outcomes (e.g. Collins et al. (2013)). Among numerous plausible approaches, using simulation can be helpful to prevent both policy resistance and negative unintended consequences in complex systems. This is possible by exploring systems pathways under diverse policy actions (Ford, 2010; Sterman, 2000). Therefore, simulation models offer the opportunity to learn about a system (i.e. SES), its behaviour, and potential responses to policy interventions.

Participatory modelling (PM) is a generic perspective that aims for involving stakeholders in processes of modelling and formal decision analysis (Voinov & Bousquet, 2010). The term stakeholder refers to any group of people, organised or unorganised, who share a common interest or stake in a particular issue or system (Garrod et al., 2013). Some stakeholders are involved in a PM effort, and their interaction is often supported by virtual worlds (e.g. simulation models) as places for discussion that aims to inform real-world decisions.

2. Ethical standpoints for modelling SES in the context of sustainability

2.1. Sustainable development

Sustainable development has its ethical roots in various principles, most evident of which is arguably the principle of intra/intergenerational justice which strive for equality or equal treatment of humans within and across generations (Kirchschlaeger, 2021). Intergenerational justice demands that each generation should consider succeeding generations "to satisfy their needs, to avoid serious harm and to have the opportunity to enjoy things of value" (Thompson, 2010). Reaching intergenerational justice implies addressing the issue of justice in the present generation (i.e. intragenerational justice) (de Vries, 2019). This continuum is necessary to achieve transformational pathways of "equitable sustainability" (Leach et al., 2018).

Connected to intergenerational justice is the precautionary principle (Raffensperger & Tickner, 1999), implying that "we should avoid activities that we have reason to believe could do serious harm to either present or future people" (Thompson, 2010). Precaution is important when the potential harm is irreversible (e.g. loss of biodiversity, human health impacts). The precautionary principle has four main components (Kriebel et al., 2001): (i) taking preventive action in the face of uncertainty; (ii) shifting the burden of proof to the proponents of an activity; (iii) exploring a wide range of alternatives to possibly harmful actions; and (iv) increasing public participation in decision making.

2.1. Human rights

Human rights set a minimum standard to protect human dignity (Kirchschlaeger, 2016), relying on the principles of freedom, equality and justice (Kirchschlaeger, 2013). It therefore has elements overlapping with those of sustainable development. Article 1 of the Universal Declaration of Human Rights states that "All human beings are born free and equal in dignity and rights. They are endowed with reason and conscience and should act towards one another in a spirit of brotherhood". Among its characteristics, universality is perhaps human right's strongest attribute, as it "entails that humans are human rights holders and that their human rights need to be respected, protected and realized" (Kirchschlaeger, 2021). Human rights are therefore an ethical common ground for every human being and human endeavour (Kirchschlaeger, 2016).

Scientific progress encompasses human rights. As an essential part of human existence, human rights protect scientific enquiry, ensuring academic freedom and serving as a fundamental point of reference for scientific practice (Kirchschlaeger, 2013). Sustainability science is part of the wider context of scientific progress (Kates, 2011), therefore is subject to human rights considerations. Sustainability scientists (e.g. socio-environmental modellers) are responsible for human rights protection by: (1) respecting human rights; (2) contributing to the realization of human rights; and (3) setting priorities according to human rights. These duties can take a negative or positive outlook: by not doing something in order to contribute to the realisation of human rights, or by doing something in order to contribute to the realisation of human rights, respectively.

3. Ethical considerations of the modelling cycle

Perhaps one of the most important realizations to start discussing the ethical implications of simulation models is to understand them as "engineered" artefacts (Olaya, 2014). As such, models are built with a purpose and are not neutral (Olaya, 2016). They rather are ethically charged entities (Palmer, 2017), embedding the values and worldviews of their crafters. This has important implications for any participatory approach, with both modellers and stakeholders taking an active and deliberative role during the model building process.

The current section explores ethical considerations in the context of a PM cycle. This research relies on Videira et al. (2010) as a relevant simulation based participatory framework in the context of sustainability. These authors consider various phases, including: (1) Scoping and abstraction; (2) Envisioning and goal setting; (3) Model formulation and confidence-building, (4) Simulation and assessment[1].

Asking ethical questions is a practical approach to integrate ethics into PM. Ethical questions inquire about values and responsibility, particularly regarding conflicting notions of the good (Ormerod & Ulrich, 2013). Pruyt and Kwakkel (2007) and Palmer (2017) offer a set of ethical questions that can guide the implementation simulation models (i.e. System Dynamics). However, it is important that these questions are asked following a logical order. To aid this, this article proposes the classification of these questions across the PM modelling cycle, as proposed by Videira et al. (2010).

Ethical questions are relevant for the SD stakeholder participation cycle as they deal with matters that affect people and the environment. Here the ethical standpoints of human rights and sustainable development need to be explicitly considered. Table 1 shows some relevant ethical questions to be examined across SD applications in the context of SES. The proposed set of questions is not

[1] We exclude the last stage of Videira et al. (2010) cycle ("Evaluating and monitoring"). This is justified as the current framework is oriented to policy decision analysis rather than on implementation

Table 1. Guiding ethical questions across a participatory modelling framework. Questions in bold are proposed in this paper, with the remainder from various sources: Pruyt and Kwakkel (2007)*, Palmer (2017)**, (Stave, 2010)† ..

Scoping and abstraction	*Envisioning and goal setting*	*Model formulation and confidence building*	*Simulation and assessment*
• Who matters? * • What matters? * • What time horizon matters? * • What are the boundaries of the system/model to be considered? * • What is the time frame considered? * • Who participates? * • **Whose world-view, value system, perspective, and interests are taken into consideration?** • Who decides from what perspective? * • What is the role of the analyst? *	What dimensions are considered important? * Do the participants/stakeholders determine the dimensions to be considered? * **What is "sustainability" in the specific context for different stakeholders?** What do the stakeholders want to "sustain" and for how long? † **Is there agreement regarding vision of a desired sustainable future" among stakeholders? If not, whose perspective is more visible?** **Who might be positively or negatively impacted if this vision is reached?** **Are the visions of a "sustainable future" intra/intergenerationally just?** **Do the visions of a "sustainable future" prevent potential harm?** **Does the envisioning and goal setting potentially infringe human rights?** **Does the envisioning and goal setting phase take active responsibility in human rights protection? How? - by respecting human rights? by contributing to the realization of human rights? by setting priorities according human rights?**	• Have the modeller/analyst made all possible input to the model as objective as possible? ** • How have the modeller/analyst introduced bias into the model? ** • How accurate is the representation of society in the model? ** • **Does the model reflect the structure found in the real-world?** • What other design options are possible? ** • **Does the model reflect the behaviour of the real-life problem/system based on a selected set of indicator values?** • **Do stakeholders agree to use the simulation model based on its capabilities to balance the complexity reflected in the conceptual maps and the simplicity required for quantification?**	Will the model be used to develop policy? ** What is the level of uncertainty (robustness)? ** What will the policy do to society if the causal assumptions in the structure are wrong? ** Have the modeller/analyst communicated the uncertainty to decision-makers? ** Will the policy developed from the model create harm for society if the assumptions are indeed incorrect? ** Does the policy produce the good for which It was intended? ** Are there unintended side effects? ** Do the side effects of implemented policy indicate that the model design is inaccurate? ** **How to weigh the criteria and assess the performance of policy options? (who selects the criteria? Why? To what end?)** **How can stakeholders incorporate the insights of the "envisioning and goal setting" to inform their decision-making process?**

exhaustive, it is rather meant to be a starting point to promote a discussion about the ethical implications that emerge across the participatory modelling cycle. The following sections offer a detailed discussion of the questions applicable within each phase of the stakeholder participation cycle.

3.1. Scoping and abstraction

Practical questions such as delimiting the problem or system in space and time requires ethical judgement. Likewise, determining who will participate and their motivations is necessary to have a wider understanding of the worldviews that will be embedded in the model. Yet, having a reflection of perspectives that are *excluded* from the modelling process is useful to be aware of the model's limitations. This reflection may highlight the need to include new stakeholders. The analysts' self-reflection about their role and motivation is key in this process. Although neutrality is desired, modelling is not objective. That is why analysts should identify their own motivations, worldviews and goals and question how they bring them into the modelling exercise.

3.2. Envisioning and goal setting

This phase's ethical challenges relate to the definition of criteria and the system's vision(s) of the future. It is important to define the criteria that will be useful to assess the performance of future interventions. To this end, the umbrella concept of "sustainability" can be used to discuss and agree on a specific definition for each particular context. An active approach towards human rights protection should be the fundamental ethical ground for the discussion of desired futures. Similarly, to envision possible desired futures will help stakeholders define more explicitly which futures they value the most and why. An in-depth enquiry regarding these aspects should consider principles related with sustainable development, such as intra/intergenerational justice and the precautionary principle. Likewise, it is important to have a vision of how the participatory process of discussing and agreeing would make certain criteria and visions of the future more visible while, almost inevitably, others become less visible.

3.3. Model formulation and confidence building

The role of the analyst is central as the main actor developing quantitative models. A conscious effort to craft a model that balances simplicity and complexity is key. Not every aspect from conceptual mapping can be quantified in a simulation model, yet the model needs to reflect the complexity and behaviour of the real system. The modellers should recognise themselves as a very likely source of bias and consider how they are actively looking to recognise and minimise it. This process can be made more transparent by involving stakeholders in the validation phase. Validation does not seek to define if a model is "right", it is rather a cumulative process of confidence building assessing the model's capabilities to reflect the structure and behaviour found in real systems.

3.4. Simulation and assessment

If a model is used to support policy, strengths and limitations need to be openly discussed and recognised by stakeholders. An important limiting aspect of simulation models is uncertainty, so recognising and communicating it is critical (Palmer, 2017). Assessing the model's robustness can help to discuss the risks of using models to support policy decision. Likewise, a structured approach to weigh criteria and assess performance of policy options can make this process more transparent. Finally, it might be valuable at this stage to re-examine the implications of choosing certain policy alternatives to reach a desired

"sustainable future", according to the "envisioning and goal setting" phase.

4. Conclusion

This article provides a structured framework aiming to make more explicit the ethical implications of using simulation tools in the context of sustainable development. Sustainable development and human rights were presented as ethical standpoints for SD across the modelling cycle. Sustainable development applications require an open discussion around the concepts of intra/intergenerational justice and the precautionary principle. Human rights protect sustainability scientists' freedom to develop research, but demand their responsibility towards human rights recognition and protection. This work serves as a starting point to further discuss and address the ethical implications of SD applications in a participatory modelling context.

Going forward, continued ethical deliberation is necessary both to prevent violations to important rights and principles but also for taking a pro-active approach to achieve the "good" intended in a "sustainable" future. As a first step, this process can start with the modellers' self-assessment as active ethical actors. Another relevant aspect is to recognise SD models as ethically charged entities that encapsulate various stakeholders' values and worldviews. Lastly, the recognition of ethics across the participatory modelling cycle should be a more widespread discussion. Simulation is a powerful tool to support sustainable policy making, and as such should point to objectives that promote human dignity and protect the environment. An ethics lens can serve as a compass to guide this process

References

Collins, R. D., de Neufville, R., Claro, J., Oliveira, T., & Pacheco, A. P. (2013, Nov 30). Forest fire management to avoid unintended consequences: a case study of Portugal using system dynamics. *Journal of Environmental Management, 130*, 1-9.

de Vries, B. J. M. (2019). Engaging with the Sustainable Development Goals by going beyond Modernity: An ethical evaluation within a worldview framework. *Global Sustainability, 2*.

Ford, A. (2010). *Modeling the Environment* (2 ed.). Island Press.

Garrod, G., Raley, M., Aznar, O., Espinosa, O. B., Barreteau, O., Gomez, M., Schaft, F., & Turpin, N. (2013). Engaging stakeholders through participatory modelling. *Proceedings of the Institution of Civil Engineers - Engineering Sustainability, 166*(2), 75-84.

Kates, R. W. (2011, Dec 6). What kind of a science is sustainability science? *Proc Natl Acad Sci U S A, 108*(49), 19449-19450.

Kirchschlaeger, P. (2013). Human Rights as An Ethical Basis for Science. *Journal of Law, Information and Science, 22*(2), 1-17.

Kirchschlaeger, P. (2016). How can we justify human rights? *Int. J. Human Rights and Constitutional Studies, 4*(4), 313–329.

Kirchschlaeger, P. (2021). *Digital Transformation and Ethics* (1 ed.). Nomos Verlagsgesellschaft.

Kriebel, D., Tickner, J., Epstein, P., Lemons, J., Levins, R., Loechler, E. L., Quinn, M., Rudel, R., Schettler, T., & Stoto, M. (2001). The Precautionary Principle in Environmental Science. *Environmental health perspectives, 109*(9), 871-876.

Leach, M., Reyers, B., Bai, X., Brondizio, E. S., Cook, C., Díaz, S., Espindola, G., Scobie, M., Stafford-Smith, M., & Subramanian, S. M. (2018). Equity and sustainability in the Anthropocene: a social–ecological systems perspective on their intertwined futures. *Global Sustainability, 1*.

Olaya, C. (2014). The Scientist Personality of System Dynamics. 32nd International Conference of the System Dynamics Society, Delft, The Netherlands.

Olaya, C. (2016). Cows, agency, and the significance of operational thinking. *System Dynamics Review, 31*(4), 183-219.

Ormerod, R. J., & Ulrich, W. (2013). Operational research and ethics: A literature review. *European Journal of Operational Research, 228*(2), 291-307.

Palmer, E. (2017). Beyond proximity: Consequentialist Ethics and System Dynamics. *Etikk i praksis - Nordic Journal of Applied Ethics*(1), 89-105.

Paterson, J. (2007). Sustainable development, sustainable decisions and the precautionary principle. *Natural Hazards, 42*(3), 515-528

Pruyt, E., & Kwakkel, J. (2007). Combining System Dynamics and Ethics: Towards More Science. 25th International Conference of the System Dynamics Society, Boston, USA.

Raffensperger, C., & Tickner, J. (1999). *Protecting Public Health and the Environment: Implementing the Precautionary Principle*. Island Press.

Spijkers, O. (2018). Intergenerational Equity and the Sustainable Development Goals. *Sustainability, 10*(11).

Stave, K. (2010). Participatory System Dynamics Modeling for Sustainable Environmental Management: Observations from Four Cases. *Sustainability, 2*(9), 2762-2784.

Sterman, J. (2000). *Business Dynamics: Systems Thinking and Modeling for a Complex World*. McGraw-Hill

Sterman, J. (2002). All models are wrong: reflections on becoming a systems scientist. *System Dynamics Review, 18*(4), 501-531.

Sterman, J. (2006, Mar). Learning from evidence in a complex world. *American Journal of Public Health, 96*(3), 505-514.

Thompson, J. (2010). What is intergenerational justice? In *Future Justice*. Future Leaders. http://www.futureleaders.com.au/book_chapters/pdf/Future_Justice/Janna_Thompson.pdf

UN General Assembly. (2015). *A/RES/70/1 Transforming our world: the 2030 Agenda for Sustainable Development*

UN General Assembly. (2022). *A/76/L.75 The human right to a clean, healthy and sustainable environment*.

Videira, N., Antunes, P., Santos, R., & Lopes, R. (2010). A participatory modelling approach to support integrated sustainability assessment processes. *Systems Research and Behavioral Science, 27*(4), 446-460.

Voinov, A., & Bousquet, F. (2010). Modelling with stakeholders☆. *Environmental Modelling & Software, 25*(11), 1268-1281.

Wu, J. (2013). Landscape sustainability science: ecosystem services and human well-being in changing landscapes. *Landscape Ecology, 28*(6), 999-1023.