

## Enhancing Autonomy for Climate Change Adaptation Using Participatory Modeling

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### ABSTRACT

Participatory modeling is commonly applied in climate change adaptation research to integrate stakeholder knowledge, beliefs, values, and norms into modeling processes. However, participation is not neutral, and current climate change adaptation research is tailored toward those with sufficient resources to adapt, as opposed to those most in need of adaptation. These are commonly marginalized stakeholder groups who remain on the social, economic, and political periphery, driving their vulnerability to climate change impacts. This paper presents the concept of autonomy in the context of multilevel governance for climate change adaptation before examining past participatory modeling approaches, illustrating the lack of application as an emancipatory tool for increasing the autonomy of marginalized stakeholder groups. Therefore, a list of 10 necessary conditions is presented for conducting participatory modeling for increasing the autonomy of marginalized stakeholder groups, strengthening multilevel governance for climate change adaptation. These theoretical foundations are intended to guide public policy and increase the societal impact of participatory modeling.

### SIGNIFICANCE STATEMENT

Responding to climate change impacts requires the strengthening of multilevel governance. An important aspect is that multilevel governance is dependent on local actors having sufficient autonomy to carry out climate change adaptation actions. Participatory climate change adaptation research can contribute to enhancing autonomy for climate change adaptation in applying participatory modeling. This paper explains why this is important, how participatory modelers need to design their research, and in what way this could contribute to strengthening multilevel governance and the wider societal response to climate change impacts.

If you're a scholar who studies the social impacts of climate change and you aren't somehow an activist what are you really?—Professor Kian Goh, University of California, Los Angeles

## 1. Introduction

The impacts of 1.5° and 2°C warming in global average surface temperature are projected to be severe (Hoegh-Guldberg et al. 2019). In the absence of significant emission reductions, the global average surface temperature will increase well beyond 1.5° and 2°C (Otto et al. 2020). Adapting to the impacts of 1.5°C, 2°C, or more extreme warming will require enhanced multilevel governance as

an enabling condition for systemic change (de Coninck et al. 2018). The formulation and implementation of climate policy and action is largely influenced by the engagement of complex governance structures spanning from the global to the national and, in particular, the local level (Di Gregorio et al. 2019; Baker et al. 2012; Celliers et al. 2020b; Williams et al. 2020b). Strengthening the engagement between these levels of governance could significantly support climate change adaptation through the reduction of risk from climate change impacts and the advancement of sustainable development (de Coninck et al. 2018).

Effective engagement between levels of governance is facilitated when each level of governance is empowered and has sufficient capacity to formulate and implement climate change actions (Bulkeley and Betsill 2013). This is of

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particular importance for the local level, which is often responsible for implementing climate change adaptation but is constrained by a lack of climate change capacity (Pasquini et al. 2015; Celliers et al. 2020b; Rosendo et al. 2018). Despite this, it is the local level at which the most appropriate adaptation measures for climate change are developed by communities themselves (Adger et al. 2003).

With roots in the ancient Greek language, *autos* signifying self, and *nomos* signifying law, autonomy is understood as the ability to act with minimal external or internal constraints and with sufficient resources and power to implement objectives (Berlin 1969). Enhancing the autonomy of local stakeholders means increasing their capacity and capability for implementing climate change adaptation measures (Dilling et al. 2019). Local stakeholder groups should therefore be actively involved and integrated into planning and research rather than passive recipients of programs designed by others (Bockstael and Berkes 2017; Dilling et al. 2019).

There is a growing body of research, however, demonstrating that current practices in climate change adaptation are failing to reach stakeholder groups most in need of adaptation (Chu et al. 2018; Webber 2019). Marginalized stakeholder groups excluded from decision-making and policy-planning processes currently remain on the periphery of climate change adaptation actions and research (Chu and Michael 2018). This is particularly problematic as local action supports multilevel governance through bottom-up horizontal diffusion or upscaling to higher climate governance levels (Wurzel et al. 2019). Therefore, the marginalization of stakeholder groups occurring at the local level is in danger of being reproduced and institutionalized at national and international levels of climate change governance. The existing inequalities resulting from marginalization mean that autonomous actions changing hegemonic structures, understood as the systematic dominance of one group over another (Gramsci 1992), are required in climate change adaptation research through the counterhegemonic inclusion of marginalized stakeholder groups.

The need for local action necessitates the inclusion of local perspectives into climate change adaptation research and has resulted in a rapid rise of participatory approaches (Döll and Romero-Lankao 2017; Newig and Koontz 2013; Norström et al. 2020). As a popular and widely applied participatory approach, participatory modeling is understood as the practice of including and combining stakeholder knowledge, beliefs, values, and norms into modeling techniques for establishing a collective vision for environmental management (Jones et al. 2009; Williams et al. 2020a). This interactive and iterative process has proven apt not only at capturing local perspectives of climate change adaptation but also at supporting social learning in pre-planned processes of interaction between scientists and

stakeholders (Williams et al. 2019; Antunes et al. 2006; Videira et al. 2009; Hedelin et al. 2017). Supporting social learning is particularly valuable for strengthening the capabilities and capacities of participants for context-sensitive climate change adaptation (Dilling et al. 2019).

However, participation is not neutral (Voinov et al. 2014), and carrying out climate change adaptation research without considering the inequality of stakeholders with regards to adaptation may serve to reproduce and reinforce existing inequalities (Webber 2019). In past applications of participatory modeling there has been little attention paid to power relations, and current method applications remain unequal in terms of access (Jordan et al. 2018). Knowledge, beliefs, values, and norms driving the participatory modeling process are largely determined by the existing hegemonic conditions advantaging the dominating group. Therefore, counterhegemonic research aimed at enhancing the autonomy of marginalized stakeholder groups would support multilevel governance for climate change adaptation (Chu and Michael 2018).

Ideally, those most affected by climate change impacts should be enabled to implement context-sensitive climate change adaptation actions themselves. Participatory modelers working with local actors are in an ideal position to contribute to enhancing autonomy of marginalized stakeholder groups, supporting multilevel governance for climate change adaptation. Therefore, the objective of this paper is both to illustrate the potential for participatory modeling to enhance multilevel governance for climate change adaptation by increasing the autonomy of marginalized stakeholder groups, and to guide participatory modelers in increasing their societal impact through an emancipatory approach. To illustrate this potential, the concept of multilevel governance for climate change adaptation will be described before embedding autonomy within this governance concept and referring this to the theoretical foundations of participatory research. Four categories of participatory research (functionalistic, neoliberal, deliberative, and emancipatory) (Alcántara et al. 2014) will then be presented, and previous applications of participatory modeling, as a participatory method, will be categorized accordingly. Revealing that, until now, participatory modeling as an emancipatory tool for increasing the autonomy of marginalized stakeholder groups has been underutilized, 10 necessary conditions for future applications of participatory modeling with relevant illustrative examples are presented to bridge this key research gap (Jordan et al. 2018).

## 2. Autonomy of marginalized stakeholder groups for multilevel climate change adaptation governance

In its broadest form, climate change governance is understood as the processes of interaction and decision-

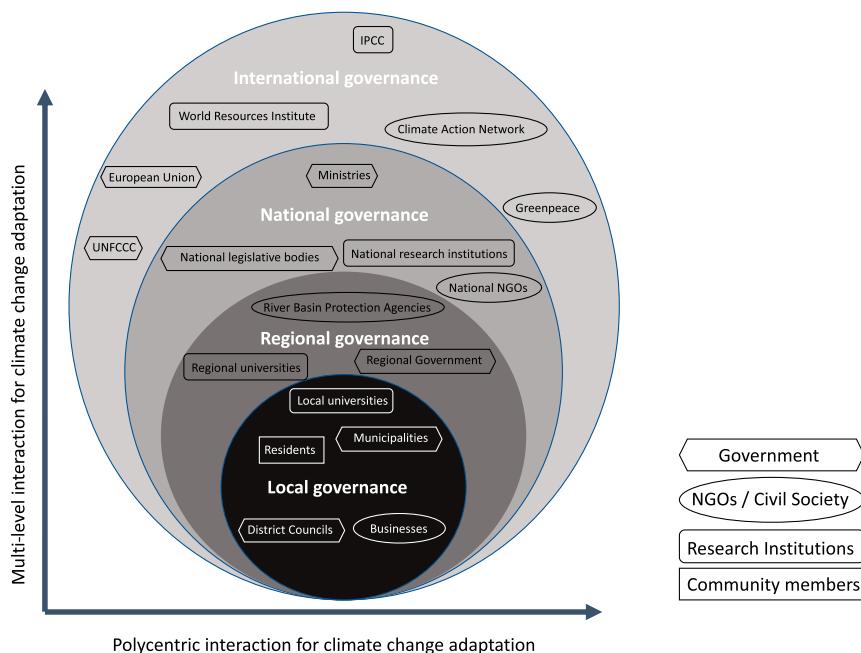


FIG. 1. Multilevel and polycentric governance for climate change adaptation (adapted from Montenegro 2018).

making among actors involved in the mitigation of and adaptation to climate change (de Coninck et al. 2018; Leal Filho 2010; Knieling and Leal Filho 2013). Multilevel governance for climate change adaptation is referred to as the establishment and implementation of climate change mitigation and adaptation policies at supranational, national, regional, and local governance scales (de Coninck et al. 2018) (Fig. 1). These levels do not engage in isolation, connecting and interacting to produce beneficial outcomes (Baker et al. 2012; Di Gregorio et al. 2019). Multilevel governance as a concept is most commonly illustrated by the example of European integration through the formation of the European Union (Hooghe et al. 2001). The network of sovereign nation states was transformed whereby the authority of decision-making and policy planning was reallocated into a system of multilevel governance (Schakel et al. 2015). As opposed to sovereign nation states, the authority of decision-making and policy planning was dispersed and shared by supranational (such as global institutions), national (such as nation states), regional (such as federal states), and local governance bodies (such as municipalities).

While some scholars have in the past viewed multilevel governance as a top-down process, it was actually devised to encompass the dispersion of authority beneath as well as above the centralized nation state (Schakel et al. 2015). Multilevel governance has therefore been described as “nonhierarchical,” recognizing that complex issues cannot be resolved at one specific level

of authority alone (Lesnikowski et al. 2017). Rather, resources should be distributed across all levels of governance (Daniell and Kay 2017). This makes it an appropriate concept for governing climate change adaptation, a highly complex, cross-cutting, and interdependent issue causing risk at multiple scales for which the dominant narrative purports there being no clear course of action, necessitating collective structural change, and hence being described as “wicked” (Vogel et al. 2016).

The intention of multilevel governance should not only be the distribution of resources to different levels of governance, but also the distribution of power to enhance autonomy at the local level (Daniell and Kay 2017). Multilevel governance for climate change adaptation is therefore also dependent on polycentric governance, referred to when multiple governing bodies, such as government entities, nongovernmental organizations (NGOs), research institutions, or community members form centers of decision-making for formulating and enforcing policy in a specific location (Ostrom 2010; Ostrom et al. 1961) (Fig. 1).

Figure 1 depicts the relationship between multilevel and polycentric governance for climate change adaptation. It stipulates that effective governance for climate change adaptation is contingent on state and nonstate entities acting independently at the local level with the support of regional, national, and international governance for providing public services that protect the environment (Homsy and Warner 2014). Effective

polycentric governance questions the presumption that only the higher levels of governance systems are relevant for climate change adaptation, and that vital line functions and responsibilities are located within local and regional levels (Ostrom 2009). This is primarily because action across multiple centers of power can create multitudinous and diverse benefits for wider society (Ostrom 2009).

However, not all governance systems relinquish centralized authority and distribute power among local governance actors (Di Gregorio et al. 2019). This can lead to adaptation measures not being sensitive to local needs, particularly in contexts prone to social exclusion and lack of access to resources and economic opportunities (Chu and Michael 2018). Marginalization is understood both as a process and as a condition excluding individuals or groups from actively participating in social, economic, and political life (Department for International Development 2017). This is particularly problematic as their marginalization leads to high exposure to climate risk, high sensitivity to damage, and low capacity for coping and recovering, making those stakeholder groups particularly vulnerable to the impacts of climate change (Moser and Satterthwaite 2008; Williams et al. 2019; Satterthwaite et al. 2018; Bai et al. 2018). In these contexts, climate change adaptation research needs to consider the underlying drivers of vulnerability, including discrimination or equity issues related to gender, political affiliation, sexual preference, or ethnic group. Paradoxically, it is those most marginalized who suffer most, while having contributed the least to climate change. If climate change research is not designed specifically with marginalized stakeholder groups in mind, their vulnerability may be exacerbated, reinforcing preexisting inequalities (Schipper 2019). Preventing the redistribution of vulnerability, this undermines the overarching goal of enhancing the resilience of society (Schipper 2019).

For effective multilevel governance for climate change adaptation, all levels of governance (Fig. 1) have to function with a degree of autonomy (Wurzel et al. 2019). Autonomous groups are not conceptualized as lawless or driven by egoistic self-indulgence but rather give law to themselves through the creation of an explicitly self-instituting community (Nicolacopoulos and Vassilacopoulos 2012).

Autonomy is usually interpreted as an alternative to existing hegemonic conditions (Böhm et al. 2010). Autonomy as self-legislation and self-regulation can be seen as an antithesis of legislation and regulation by another (Castoriadis 1975). The concept of hegemony was defined and developed as expressing the type of political relation and applied to understand concrete social formations (Laclau and Mouffe 1985). Crucially, hegemony was used to explain the patterns of class domination not only being determined by physical force

but also through cultural and ideological acquiescence (Gramsci 1992). Cultural and ideological acquiescence are closely connected to shared knowledge, beliefs, values, and norms stipulating societal organization and decision-making (Böhm et al. 2010). Counterhegemonic actions have therefore demanded the right to self-determination, organizational self-management, and independent social and economic practices for increasing autonomy (Böhm et al. 2010; Lentner 2005).

It is in the political and social sphere where alienation and marginalization occur (Castoriadis 1975). Individual autonomy on its own is incapable of overcoming this institutional hegemony, which conditions alienation and marginalization, necessitating individual and social autonomy of stakeholder groups (Castoriadis 1975). Autonomy as a concept only acquires meaning through the praxis of challenging political hegemony (Laclau and Mouffe 1985). Praxis, understood as the exercise of an art, skill or science, is what develops individual autonomy for reorientation and reorganization of society (Castoriadis 1975). Community members can be marginalized both as an individual, and via association with a specific stakeholder group. At the same time, automatization through praxis occurs not only at the individual level but also at the social level, meaning there is a dual emancipation taking place (Castoriadis 1975). Autonomous struggles affect practices of other social movements, reverberating both vertically and horizontally across governance systems (Laclau and Mouffe 1985). This is because social movements are not disconnected and isolated from one another and are not indifferent to what takes place around them (Laclau and Mouffe 1985).

Climate change adaptation actions therefore do not occur in isolation (Malik et al. 2010). Polycentric action driven by autonomous local governance stakeholders is increasingly viewed as an innovative force driving environmental sustainability (Homsy and Warner 2014). This is because the framework of multilevel governance to climate change adaptation stipulates that in taking a coproduction approach, knowledge and policy innovation can transcend the local and permeate across all tiers of governance (Homsy and Warner 2014) (Fig. 1). Community practices and innovated action taken at local governance level have shown to inform and positively influence national and regional governance systems through bottom-up policy diffusion (Rahman and Hickey 2019; Montenegro 2018). For this reason, enhancing the autonomy of local governance stakeholders in scientific research could significantly increase the effectiveness of multilevel governance for climate change adaptation.

Polycentric systems with a high degree of autonomy are particularly beneficial when national and regional adaptation plans disregard or contradict local adaptation

needs and push toward maladaptive trajectories, and for utilizing local resources (Rahman and Hickey 2019). However, the ability of local governance stakeholders to undertake autonomous action is partially dependent on the provision of sufficient resources from other tiers of governance (Baker et al. 2012). In addition, uncoordinated autonomous actions taken by marginalized stakeholders or stakeholder groups have also previously shown to unintentionally shift risk to others if not integrating the needs of the wider community (Rahman and Hickey 2019). Empirical studies have therefore shown the effectiveness of local governance in implementing climate change adaptation to be higher when undertaken in both multilevel and polycentric systems (Ostrom 2009; Homsy and Warner 2014).

There is an extensive history, particularly across the Global South, of marginalized stakeholder groups taking autonomous action for climate change adaptation (Forsyth and Evans 2013). Using the example of smallholder agriculturalists, Adger et al. (2003) describe how the autonomy of marginalized stakeholder groups has shown to enhance the ability to adapt (Forsyth and Evans 2013), illustrating the importance of autonomy for effective polycentric action (Ostrom 2009). At the same time, marginalized stakeholder groups are constrained in this regard as their vulnerability is to a large part determined by an exclusion from the state apparatus depriving them of access to resources upon which their ability to act autonomously depends (Chu and Michael 2018).

The success of climate change adaptation is therefore in part determined by the capability or capacity of marginalized stakeholder groups in carrying out actions autonomously. Capability and capacity approaches have the advantage of being sensitive to the needs of diverse communities in highly variable living conditions with different dependencies on what enables adaptation (Gupta et al. 2010; Dilling et al. 2019; Sen 1997). Strengthening capabilities and capacities driven by the needs and values of local communities, particularly marginalized stakeholder groups, could contribute to resilient futures and adaptation goals (Dilling et al. 2019). Enhancing autonomy at the local level would therefore enhance not only polycentric governance but also multilevel governance for providing the executing level with sufficient capacity and capability to implement climate change adaptation actions. Future research should focus around providing an enabling environment for autonomous climate change adaptation by building processes that empower communities and support the development of capacities and capabilities (Dilling et al. 2019; Malik et al. 2010).

### 3. Theoretical foundations and categories of participatory research

Automization of local marginalized stakeholder groups as a counterhegemonic action can assist in ensuring climate change adaptation is responsive to the needs of those most affected. If praxis in science can develop individual and social autonomy for reorientation and reorganization of society, then participatory approaches have a significant potential for counterhegemonic climate change adaptation research. Based on the need for interpretation rather than explanation, the theoretical foundations of participatory research can be found in interpretative constructivism (Katzenstein et al. 1999). Underpinning interpretative constructivism is the idea that human behavior is determined by knowledge, beliefs, values, and norms, or any other available interpretative filter through which the world is conceived (Parsons 2010). Humans make sense of and engage with their surroundings based on their respective historical and social perspective and experience, meaning the production of knowledge is always an inherently social process born out of interactions with human groups and communities (Creswell 2009). The production of knowledge through participatory processes has therefore been described as inevitably situated and partial, necessitating the consideration of ethical reflection in the process (Norström et al. 2020). Interpretative constructivist researchers commonly rely on a combination of both qualitative and quantitative data collection methods to generate and develop a theory or pattern of meaning inductively (Creswell 2009).

When applied in an intentional manner, participatory research can be considered an interpretative constructivist alternative to realist and positivist approaches for knowledge production (van der Riet 2008) and is seen as an appropriate strategy for responding to the need for democratizing expertise (Krueger et al. 2012). Participation is based on the premise that stakeholders are able to reflect on their consciousness and formulate intentions to understand knowledge, beliefs, values, and norms, revealing their reasons for action. Applications of participatory research approaches have also shown to enable the strengthening of capacities and capabilities of the participants themselves (Quigley et al. 2010), responding to the recent adaptation research agendas (Dilling et al. 2019).

Attributes inherent to the successful application of participatory research methods include active participation of stakeholders in the research process, co-ownership of research processes and outcomes, and that the investigation of processes builds on local knowledge of stakeholders, that is, their social construction of reality (van der Riet 2008; Norström et al. 2020). Based on the classification of Alcántara et al. (2014), the application of

participatory methods can be applied in a functionalistic, neoliberal, deliberative, or emancipatory approach.

The functionalistic approach works on the premise that by including individual expertise of community members or the private sector, the optimal solution to a problem can be found for everyone affected. Only those who are well acquainted with the issue of study are included in the process, responding to the technocratic goal of incorporating and integrating stakeholder knowledge into scientific processes.

The second category is termed the neoliberal approach. Establishing the well-informed preferences of participants and potential effects of certain measures can help optimize trade-offs and cobenefits for the wider public. It works on the premise that people are rational entities bargaining for the best possible outcome for all. In this scenario it is important that participants are selected at random to best represent society, legitimizing the outcome of the research process. It is also important that the cost of organizing the research project does not outweigh the resulting benefit.

The third approach is termed the deliberative approach. This necessitates a diversity of participants and plurality of values for legitimate and sustainable decision-making. Essential to the deliberative approach is reciprocal understanding, transparent decision-making and integration of societal and cultural values for generating new knowledge. Discussions can also develop into arguments, which should not be discouraged in nonhierarchical and nonhegemonic settings. This discourse can help in translating individual interests into common goals. The aim of the deliberative approach is open dialogue and the formation of consensus.

However, social justice concerns are intrinsic to the participatory research paradigm (Creswell 2009), at the center of which lies the enabling of structured transformation and the altering of living conditions of stakeholders (van der Riet 2008). Drawing on critical social theory, participatory research should empower its participants by uncovering the “mechanisms for producing, maintaining, and legitimizing social inequalities and domination (Paulston, 1979)” (Maguire 1987, from van der Riet 2008). Hence, Alcántara et al. (2014) added a fourth category that is of particular interest for enhancing the autonomy of marginalized stakeholder groups. Termed the emancipatory approach, it offers the opportunity of generating new knowledge through including those stakeholder groups previously marginalized from the research process and amplifying their voice.

#### **4. Participatory modeling for increasing autonomy of marginalized stakeholder groups in climate change adaptation research**

Participatory modeling is a participatory method commonly applied in climate change adaptation research

(Williams et al. 2019; Sedlacko et al. 2014; Videira et al. 2009; Antunes et al. 2006; Pagano et al. 2019; Giordano et al. 2017). As an iterative and interactive process, it can be supported by computer-aided modeling and communication tools (Hedelin et al. 2017) in which an explicit and shared decision-making system is constructed and simulated (Jordan et al. 2018). The key variables and relationships between variables affecting the dynamics of a system are defined by the participants (Voinov and Bousquet 2010; Williams et al. 2019) and can form the basis for further investigation and research (Williams et al. 2018). In contrast to purely physical modeling, the model boundaries are not set in a way that excludes societal aspects, transcending scientific disciplines. The inclusion of knowledge, beliefs, values, and norms upon which societal decision-making depends is necessary for science to influence policy (Voinov et al. 2014).

One of the key advantages of applying participatory modeling in climate change adaptation research is the ability to consider key variables at different spatial and organizational scales, making it particularly appropriate for climate change research (Williams et al. 2019, 2020a). Furthermore, multistakeholder processes can raise the awareness of urban planners and environmental managers on the multifaceted and complex nature of risk to climate-induced environmental hazards that transcend spatial and organizational scales (Dodman et al. 2019). Identifying key variables along with their relationships facilitates the development of abstractions representing the system under investigation, yielding an improved understanding of system behavior and feedback relationships, and of the perceived underlying structure of a system (Jordan et al. 2018). This is crucial, as it allows for presenting scientific evidence while considering the way in which knowledge, beliefs, values, and norms affect decision-making and action (Voinov et al. 2014; Voinov and Gaddis 2017). Participatory modeling can support the analysis of long-term consequences of decisions and policies (Videira et al. 2009; Williams et al. 2019), allowing for the codevelopment of a descriptive and normative knowledge base upon which decisions regarding climate change adaptation can be based (Hedelin et al. 2017).

The structured representation of knowledge systems through aggregated models has shown to be essential for environmental decision-making (Jordan et al. 2018). While it is challenging to quantify social and physical variables to produce numerical system outputs, a particular strength of participatory modeling is the necessity of involving stakeholders, broadly understood as those who either affect or are affected by a decision (Scheffran 2006), into the model-building process. Codeveloped models

have the potential to decrease hegemonic structures through bridging power dynamics, facilitating collaboration, and providing entry points for epistemic and logistical stakeholder participation (Jordan et al. 2018). Past applications include environmental management, policy studies, consumer analysis, conflict resolution, and climate change adaptation.

Hovelynck et al. (2010) use participatory modeling for integrating stakeholder knowledge in a technocratic process, an appropriate example of the functionalistic approach. A clear example of the neoliberal approach is Vlachos et al. (2007), who apply participatory modeling to identify trade-offs and cobenefits of management decisions on the efficiency of supply chains. Allington et al. (2018) use participatory modeling to foster dialogue and enhance collaboration between affected stakeholders in socioecological systems, constituting a deliberative approach. Applying participatory modeling as a tool for creating dialogue between parties with different interests and identifying better decisions through a plurality of perspectives represents a combination of deliberative and neoliberal approaches taken by Videira et al. (2009). With the primary goal of a joint problem definition and consensus building, Antunes et al. (2006) take the deliberative approach, while Hedelin et al. (2017) opt for a functionalistic and deliberative approach in the search for improved knowledge integration and mutual understanding.

Upon reviewing the literature for previous applications of participatory modeling, it becomes eminently clear that the use of the emancipatory approach as a normative requirement with marginalized stakeholder groups remains underutilized. There may be several reasons for this. Commonly, participatory modeling processes are carried out in the context of research projects that seldom have emancipatory outcomes as a clear objective. The success of the emancipatory approach for enhancing the autonomy of stakeholders is also challenging to evaluate and demonstrate to principal investigators and reviewers. In addition, there is an understandable unease among researchers in being challenged on their own beliefs, values, and norms, opening the possibility of difficult debates and conflicting viewpoints among research teams. Emancipatory approaches are also perceived as being costly, associated with a high degree of risk, and too complicated.

This is seemingly a missed opportunity, as participatory modeling can significantly enhance adaptive capacities and capabilities (van der Riet 2008), making it highly appropriate for increasing the autonomy of marginalized stakeholder groups. Crucially, participatory modeling can encourage learning and cooperation among participating stakeholders (Tuler et al. 2017).

Active engagement in participatory modeling for climate change adaptation can therefore in itself constitute a process of empowerment through allowing marginalized stakeholder groups to create an image of self. Empowering marginalized stakeholder groups through participatory modeling can help to develop more personal and social agency to overcome traditional power structures leading to enhanced autonomy and increased adaptability. And yet there are no “formal community best practice standards to facilitate participatory modelling processes in a fair, transparent, and scientifically sound manner” (Jordan et al. 2018).

## 5. Necessary conditions

The following list of 10 necessary conditions, understood as normative requirements for participatory modeling to increase the autonomy of marginalized stakeholder groups, is intended as a contribution to bridging the gap identified by Jordan et al. (2018). They have been developed from experiences in applications of participatory modeling, in addition to further examples provided in the climate change adaptation literature and adaptation theory.

- 1) Ensure inclusion and incorporation of marginalized stakeholder group representatives in the modeling process. This can be undertaken through sampling in accordance with geographic and demographic information, such as location, gender, political affiliation, sexual preference, or ethnic group (Montesanti et al. 2017; Chu and Michael 2018). Alternative methods include expert interviews, focus group meetings, or policy document analysis. This process is made easier by highlighting and addressing barriers for inclusion (Butler and Adamowski 2015). In any case, contacts to local researchers and community leaders are essential, as approaching marginalized stakeholder groups without consent or having already established a trusting relationship is rarely appropriate.
- 2) Compensate participants for their involvement, ideally through remuneration. In many cases this will not be possible due to research budget constraints and national regulations. In cases in which it is possible, remuneration needs to be undertaken that is sensitive to local contexts and community dynamics. However, if no form of compensation is offered, only those with sufficient resources can afford to participate in the research. This is commonly not an option for representatives from marginalized stakeholder groups and is often overlooked in research projects.

- 3) Concerning research design, participant inclusion should begin not only during the data collection phase but earlier in the design phase (Young African Leaders Initiative 2010). Stakeholder expertise can add valuable insight during the research planning and problem formulation phases (Voinov et al. 2014). Consultations can take place through expert interviews or group focus meetings (Williams et al. 2019).
- 4) The process is most effective at enhancing the autonomy of marginalized stakeholders when they themselves drive the process (Alcántara et al. 2014). In the case of participatory modeling, this would involve carrying out a prior workshop or training course with representatives of marginalized stakeholder groups, teaching prospective facilitators and modelers the techniques and skills required.
- 5) In terms of facilitation, communication techniques need to be selected with which participants are most comfortable (Butler and Adamowski 2015). This will ensure that all voices are heard and generate a higher output in terms of knowledge elicitation. When problematic interpersonal interactions manifest in conversations and debates, facilitators need to be able to mediate and ensure division does not dominate the process (Butler and Adamowski 2015). It is also important to create an environment in which participants are encouraged to reflect and evaluate the facilitation process (Allington et al. 2018).
- 6) In cases in which it is not possible or pragmatic for representatives of marginalized stakeholder groups to drive the process, participatory modelers working with marginalized stakeholder groups need to be aware of the underlying hegemonic relationships between participants, and be intentional about counterhegemonic actions to shift power dynamics (Rubin et al. 2016). Facilitators themselves also need to be aware of their privileged position as outsiders and acknowledge the power that is embedded structurally in research processes (Ross 2017).
- 7) Allow participants to focus on what is important to them (Ross 2017). This is easier if the process is led by representatives from marginalized stakeholder groups themselves. By providing participants with the power to enact research, knowledge production is placed into their hands and outcomes are more sensitive to the local context (Ross 2017).
- 8) Participatory modelers must pay attention to what they say and how they say it (Butler and Adamowski 2015). Using nondiscriminatory language and avoiding generalizations and stereotypes that may be exclusionary, offensive, or derogatory is crucial when working with marginalized stakeholder communities (Young African Leaders Initiative 2010). Language is a form of power, and academics must acknowledge this hegemonic relationship, commonly accentuated through their increased access to social goods such as money or formal education, and restrain themselves from using jargon that would serve to alienate marginalized stakeholder groups (Reid 1999; Jordan et al. 2018).
- 9) If participatory science is to produce understandable knowledge and contribute to sustainable development of society, then the results of science have to be published in an accessible format (Schöpfel 2017). Participants need to see their personal narratives in the research, and open access is a minimum requirement, with current knowledge production and exchange mechanisms skewed toward high-income research contexts (Schöpfel 2017; Jordan et al. 2018). The open access requirement, however, goes beyond scientific publications and extends toward dissemination in a language and format understandable to those participating. This is particularly important for the dissemination of participatory modeling outcomes, which may not necessarily be sensitive to the internal assumptions established during the model building phase (Krueger et al. 2012). Alternative formats include blog posts, storylines, maps, or other visualizations (Williams 2019; Celliers et al. 2020a).
- 10) While outcomes of science processes often remain on the periphery, best efforts need to be made on the part of the research team to bridge the gap between science and policy making. The success of participatory modeling is heavily dependent on stakeholder involvement, which will become challenging if there are no tangible influences of the research on policy processes. Participatory modeling is not successfully accomplished without actual use and action based on outcomes. When policy impact is not immediately achievable, researchers need to be able to demonstrate that a concerted effort was made. Otherwise, they risk being perceived as treating participants from marginalized stakeholder communities as research objects as opposed to subjects. In addition, researchers need to ensure their interest in the project does not dissipate once “the model is running, the funding is gone and the papers are published” (Voinov et al. 2014), as this would serve to further alienate marginalized stakeholder groups and decrease the likelihood of counterhegemonic action.

For involving and incorporating knowledge from marginalized stakeholder groups, Butler and Adamowski (2015) offer some useful examples from experiences

in water resource management. Facilitating transdisciplinary multistakeholder participation processes can be challenging, and potential enabling factors as well as barriers are discussed in Bracken et al. (2015). A useful resource specifically in the art and pitfalls of consensus building can be found in van de Kerkhof (2006), while Allington et al. (2018) provide an effective method for allowing participants to evaluate and reflect the participatory mapping process.

## 6. Conclusions

This article has shown how enhancing the autonomy of marginalized stakeholder groups through emancipatory applications of participatory modeling techniques may contribute to more just outcomes of climate change adaptation research and practice. After presenting autonomy in the context of multilevel governance for climate change adaptation, this paper illustrates the potential of participatory modeling to enhance the autonomy of marginalized stakeholder groups. Participatory modeling offers a useful tool for integrating knowledge, beliefs, values, and norms into scientific analysis of adaptation options, which is crucial for outcomes to influence action. This has the potential of enhancing autonomy of the marginalized stakeholders both on the individual and on the group level. Increased autonomy can significantly contribute to adaptive capacity and enhance the functioning of both multilevel and polycentric governance systems.

The most effective climate change adaptation measures are developed and implemented by local stakeholder groups themselves. This paper is not to be understood as advice for people from marginalized stakeholder groups on how to adapt to climate change but rather for academics on how to conduct participatory research, specifically participatory modeling, in a way that enables the autonomy of marginalized stakeholder groups and empowers them to undertake action. Hence, 10 necessary conditions for emancipatory modeling approaches have been presented.

In conclusion, it is important that participatory modeling is not exploited or misused for satisfying scientific evaluators or administrative requirements, but that it is applied for social justice and counterhegemonic actions in the true spirit of participatory research and to increase the autonomy and empower marginalized stakeholder groups in climate change adaptation research.

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