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Breaking Boundaries in Resilience Planning

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Breaking Boundaries in Resilience Planning

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We describe a framework for deploying agent-based models as a tool for decision-making during resilience planning, with an emphasis on flood mitigation. Prior work has demonstrated that agent-based models can be effective tools for modelling evolving community flood resilience and risk perception when they incorporate elements of individual decision-making. We argue for extending this methodology and incorporating it into regional infrastructure and resilience planning in order to 1) create more distributed and robust green infrastructure implementations and performance management systems; 2) provide a critique and alternatives to existing planning and delivery processes based on public sector jurisdictional boundaries; and, 3) validate and improve the modelling process by connecting it directly to stakeholder decision-making processes. This final point will effectively merge these systems-centric modelling approaches with human-centred community organising that employs various co-design methods.

In regard to the ABMs, co-design methods can be a useful source of real-world data about individual decision-making that can inform and validate iterations of the models. For stakeholders, they can be a valuable source of information and education about flood risk and climate-related impacts that might not be available through other channels. And finally, hands-on workshops coupled with potential small implementation grants can be effective ways of providing skills and incentives to stakeholders who may wish to undertake projects on their own property, reshaping the way green infrastructure planning and implementation can be accomplished.

KEYWORDS: systemic design, boundary critique, resilience, flooding, recursive design

RSD TOPIC(S): Methods & Methodology, Architecture & Planning, Cases & Practice

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Presentation summary

Changing global climate will radically alter local weather conditions in ways that are unique to different geologic, atmospheric, and topological regions. Some areas may experience extreme drought while others endure more powerful storms and frequent flooding; others may oscillate between these extremes. This is to say nothing about other effects of climate change indirectly related to precipitation, such as sea-level rise, mass migration, food scarcity, or wildfires. The list of potential climate impacts is extensive and daunting, and, as the most recent IPCC report indicates (IPCC, 2022), largely unavoidable.

That report also indicates that it is prudent to examine infrastructure planning with an eye toward mitigating the most likely impacts of climate change in order to create the most resilient communities possible. Resilience priorities will necessarily differ from region to region and locality to locality, but basic methods and approaches that can transfer across regions and can theoretically be adapted to different or multiple threats will be highly valuable tools. In this work, we describe a mixed-methods and multi-scale or recursive design framework (Barba, 2019) for regional resilience planning that integrates common methods from systems science (agent-based models or ABMs) with design (co-design specifically). We outline a study, currently in progress, that will test the validity of this approach as it applies to stormwater management and flood mitigation in a pilot community as a proof-of-concept and then extrapolate to describe how a generalisation of the methodology would be an aid to resilience planning regardless of the specific climate impacts that need to be addressed.

Background

Typical planning approaches to stormwater management and flood mitigation utilise hydrologic models, material costs, and existing infrastructure to determine the parameters of effective intervention (EPA, 2016). There are a number of potential issues with these approaches that range from poor communication of risk to ecosystem damage due to overdevelopment. Agent-based modelling approaches (cf. Tonn & Guikema, 2017) offer an alternative or complementary method that can aid the planning process to better plan infrastructure investment. Because ABMs can effectively model the outcomes of individual small-scale decisions and actions, they provide a new and useful source of data to be incorporated into the planning process. Furthermore, by combining this approach with community-based co-design methods, the potential exists to further refine both approaches, improving the models' accuracy by better understanding individual behaviours and choices while also improving the effectiveness of those on-the-ground co-design interventions by providing simulations that define and test constraints, targets, and metrics for those interventions that can even be done in partnership with stakeholders. Ideally, this combined mixed-methods approach can increase not only aggregate flood resilience in a community but also achieve additional desirable aims such as small-scale economic benefits to stakeholders; increased education around land and water uses; improved infrastructure maintenance; more diverse technological solutions; and improved ecosystem services; as well as other qualitative benefits to health and well-being.

Methodological overview

At the heart of this recursive methodology is a *meet-in-the-middle* approach that combines top-down systems modelling and measurement with organising through co-design. At the planning level, agent-based models are created by using regional data sources to determine which patterns of green infrastructure development (locations and requirements) enable the most robust regional-scale outcomes and what role individual decisions play in that process. In parallel, community-driven bottom-up design methods are used to engage various community stakeholders to achieve buy-in, distribute material and knowledge resources, and inform the models themselves to account for the real-world inputs to stakeholder decision-making. Although ABMs have not been used very much in systemic design (Jamsin, 2018), participatory design methods are quite common. Work such as "Systemic Design in Food Security and Resilience" (Darzentas & Darzentas et al., 2018) engage stakeholders directly in collectively building a holon based on emerging stakeholder needs in resilience planning, while Taysom & Crilly's (2016) engagement with stakeholders results in a multiscale or recursive design approach in regard to resilience planning. Connecting these two scales of intervention together is done iteratively through ongoing measurement of implementations and engagement with stakeholders. Quantitative measures can be used to validate the model and determine if resilience targets are achieved, while qualitative measures can be used to determine the perceptions of the implementations (including planning processes, the models, and the infrastructure) and their impact on community perceptions of risk and resilience.

Although our approach is focused on stormwater management and flooding resilience, the general methods outlined can be applied to other areas of climate mitigation, adaptation and resilience planning. Even more interestingly, high-quality ABMs of community behaviour can also be an aid to disaster response after a flood or other damaging events as a means of predicting human response for resource delivery or distribution of emergency information. The methodology outlined here has the ability to influence community resilience in terms of resisting impacts, recovering from impacts, and ultimately aiding community transition in response to permanent environmental change. Valid models of human decision-making that are informed by stakeholder-supplied data rather than the assumptions of modellers are a potentially important tool in community survival at all stages of climate impact, from assessment of risk to resilience planning and implementation, and ultimately to disaster response and restoration of the community.

Contribution to boundary critique

Boundaries are an integral part of systems thinking. The definition of boundaries, in turn, establishes what is and is not part of the system of interest and, therefore, is a part of the analysis. Furthermore, boundaries also provide the context for any designed interventions that both constrain the possibilities for action and colour how one characterises and measures the results. In the kind of planning and resilience work that we describe, jurisdictional and political boundaries are of paramount importance (although socioeconomic and other boundaries are also quite relevant) as these determine who takes action, what the possibilities for action and intervention might be, and who ultimately will receive the benefits of those actions. This is often a major roadblock to lasting intervention.

Rivers and floods do not obey our municipal boundaries, and interventions taken in one jurisdiction alone are often inadequate at best and counterproductive at worst, as they can undo what another jurisdiction is trying to achieve. What is needed is a suite of tools that allow for organisation and planning around natural and social boundaries rather than political or engineering boundaries. It's our hope that ABMs can effectively describe new ways of organising small-scale and individual stakeholder action that are agnostic to political (and other) boundaries and, in doing so, provide an evidence-based conceptual tool that enables new planning processes and better outcomes, as well as a roadmap to more effective and distributed resilience planning.

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