Chapter 25
Participatory Agent-Based Modelling for Flood Risk Insurance

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Abstract In the context of climate change adaptation, there has been a recent research focus on the impact of flood insurance on flood risk reduction behaviour. ABM has been recently used in such researches to model the interaction of stakeholders. Building on this foundation, we propose the integration of participatory methods to capture the socio-cognitive and behavioral aspects of flood risk insurance, which have been missed in such models. The results of our suggested line of research on *Participatory ABM for Flood Risk Insurance* can support public and private sector considering their preferences and contextual requirements.

Keywords Flood risk insurance · Participatory methods · Agent-based modeling

Introduction

Policy makers and governments have recently showed growing interest in using insurance as an economic flood risk management tool [12]. However, the impact of insurance policies go beyond the financial recovery: it can directly or indirectly influence the behaviour of those at flood risk. While insurance can encourage more risky behavior (e.g., property development in high risk locations with reliance on the insurance support) but can also trigger desirable risk reduction behaviors, through incentive mechanisms like risk-base pricing, deductibles, and no-claims bonuses [11].

Recent studies have shown that actors' responses to flood insurance policies strongly rely on socio-cognitive and behavioural aspects of decision making such as

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risk perception, dynamic preferences, and social values [6]. To incorporate human behavioral aspects in flood risk analysis, Agent-Based Modeling (ABM) has been used in a few number of studies [5, 9]. Building on such an agent-based perspective, we see the need for integrating stakeholders' knowledge and perceptions using participatory techniques. In this study, we suggest the combination of *participatory modelling methods* and ABM as an approach to capture and present the contextualized human behavior in simulating impacts of flood insurance policies. Then, we explain applicability of three participatory methods i.e. narrative data analysis, fuzzy cognitive mapping and role-playing game in this approach.

Flood Risk Insurance and Human Behavior

Flood insurance policies and their implementation differ widely across countries. It can be provided by the private insurance market alone (e.g., flood insurance in Ireland), with government intervention (e.g., the National Flood Insurance Program in the Us), or a combination of both (e.g., Flood Re in the UK). It can be mandatory (e.g., in France and Spain) or voluntary (in most of countries). Flood insurance can also be subsidized (reinsurance under Flood Re in the UK), indemnity-based (e.g., in Ireland and Australia), or index-based (e.g., mostly in developing countries) [11]. People's acceptability and reactions to such insurance policies might be complicated. For example, [13] show that Hungarian government subsidy in insurance rates has caused high concentration of properties in high-risk areas and has also been ineffective to attract insurance buyers in this area.

ABM has recently been used to simulate human behaviour in response to flood risk using the social-psychological theories—e.g., protection motivation theory. In such theories, human risk adaptation behavior results from individual's (1) threat appraisal and (2) coping appraisal, both of which highly depend on human perceptions in terms of *perceived* vulnerability, *perceived* flood severity, and *perceived* effectiveness/feasibility of interventions [5]. However, how to capture such perceptions is still an open question. We suggest that a combination of *participatory methods* and ABM would be a robust modelling approach, providing supportive evidence for flood risk insurance analysis.

A Methodological Toolbox

Participatory methods are used to actively engage actors in co-design, co-analyze and co-implementation of policy option simulation [14] and involve their heterogeneous perceptions, preferences, and values in the process of modelling [7]. In this section, we introduce three methods that can be used in integrating human behaviour in the ABM of flood risk insurance.

Narrative Data Analysis (NDA) techniques provide formal structures for the process of using narrative data (collected via interviews) to develop decision making processes in ABM. NDA generally consists of four stages: (1) conducting interviews, (2) transcribing them into text, (3) analyzing text, and (4) coding decision rules for an ABM [3]. Using narrative data to develop ABM of flood risk insurance offer the possibility to gather additional valuable information—not achievable by questionnaires—and result in more empirically grounded and contextualized simulations of human flood adaptation behavior. However, developing a systematic process for translating flood-relevant narrative data into ABM program codes requires further investigations.

Fuzzy Cognitive Mapping (FCM) is a kind of mind mapping method in which stakeholders collaboratively develop a cognitive map (a weighted and directed graph). In an FCM, components of a system and their casual relationships are identified and semi-quantified via stakeholders' perception [10]. FCM can enable stakeholders to represent their decision making process. Moreover, FCM can capture the uncertainty of human perceptions by translating verbal causal weights (low, medium, high) into numerical values. To collect flood-related decision making process, for instance, actors can be asked to identify (1) the actions they take to reduce flood risk, (2) the conditions, drivers, barriers and timing of those actions, and (3) the impact of each action on the flood risk of properties. There have been limited number of studies on using this method to inform actors' decision rules in the ABM (e.g., [4, 7, 8]) which can be used as a basis for FCM-based ABM for flood insurance analysis.

Role-Playing Game (RPG) is a participatory method in which players are asked to behave as particular actors in a roughly defined setting [1]. Observing the decisions and actions made by game-players can reveal implicit social rules, norms, and values, which are not easy to grasp during survey questioners and interviews. To develop an RPG-based ABM for flood risk insurance, the players can participate in a game, specified by flood-related barriers/incentives and under different flood insurance policies. Gathering data on various rounds of game play can provide justifications for formulating ABM decision rules. In a two-sided relation, one can also use the output of ABM for updating insurance policies in RPG. There are some games developed to present, model, or train the flood risk reduction activities, which can be integrated with the ABM of flood risk insurance, e.g., *Extreme Event Game*, *FloodSim*, and *Stop Disaster*.

Challenges and Opportunities

Each participatory method has its own challenges and potentials. FCM-based ABM provides an easy-to-use software for non-modelers who want to capture and represent the perception of a large group of stakeholders. However, it weakly represents spatial and temporal aspects of the problem. RPG-based ABM, on the other hand, is effective for creating synergy among stakeholders and observing actors' behaviour in response to each other's actions and environmental changes. However, developing and playing games can be costly in terms of time and resources. Moreover, verifying whether game plays correspond to actions in real life is challenging. Knowing potentials/challenges of these methods, to identify the appropriate participatory ABM for flood risk insurance, we need to consider context-related specifications including (1) the spatial and social heterogeneity of decision makers, (2) the scope and specificity of decisions, and (3) inherent complexity and uncertainty of the human decisions. Moreover, the technical issues of each methodology relating to translating qualitative data into formal rules need to be further studied. This work is the first attempt to propose the application of participatory ABM for flood risk insurance. We plan to apply our participatory approach by collecting and formalizing human decision making processes for flood risk and integrating them into an existing ABM [2]. This model can be used to test the impact of the UK insurance policies on the uptake of flood risk reduction measures.

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