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Archetypes of local governance for flood risk reduction decision-making under uncertain climate change futures

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ABSTRACT

Urban coastal communities are among the most vulnerable to flood hazards, with these threats set to increase under climate change. Knowledge of how uncertainty shapes passive or proactive local decision-making processes of climate adaptation remains sparse – with significant potential to inform resilient and sustainable futures. To understand these decision dynamics, we developed a serious game to simulate the local governance roles, resources, and assets involved in managing flood risk under uncertain climate scenarios. Using data on the actions of game workshops conducted in the Philippines, we identify three distinct archetypes of collective adaptation decision-making: (1) Hierarchical Alliances; (2) Passive Enthusiasts and (3) Deliberative Strategists. We then examine how these archetypes respond to situational, temporal, choice, and outcome uncertainties present in climate change scenarios, uncovering six strategies used to act, reduce, supress, and forestall uncertainties: (a) resource sharing; (b) coordination; (c) early action; (d) mobilising values; (e) transferring accountability; and (f) risk balancing. Our results show how different archetypes perform in adaptation decisions, offering new guidance on how to structure local governance mechanisms in flood planning under climate change impacts.

1. Introduction

Flood risks are becoming increasingly dynamic due to the acceleration of anthropogenic activities and climate change (Li et al., 2019). Over the last two decades, flooding affected 1.6 billion people and inflicted $651 billion (USD) in economic losses (CRED, 2023). Climate change adaptation has thus become an imperative to improve community resilience, especially in the Global South where disaster losses are highest (Dordi et al., 2022). It is extensively documented that the implementation of adaptation measures depends upon the capacity and effectiveness of urban governance and decision-making processes (IPCC, 2023). For this reason, the United Nations Sendai Framework (2015) recognises that strengthening disaster risk governance is a key priority. Recent work has highlighted the need for foresight and path-shifting to establish collective visions and co-production of knowledge necessary for transformative resilience in urban governance systems (Asadzadeh et al., 2023).

Moure et al. (2023) suggest that robust adaptation planning decisions are regularly undermined by climate change uncertainties as individuals tend to respond passively when faced with unknowns. For instance, uncertainties persist around the frequency and magnitude of flood events and the effectiveness of competing policy actions (Mach et al., 2016), encouraging decision-makers to defer adaptation until more information becomes available. It is crucial for disaster risk reduction strategies to grasp how individuals perceive risks and make decisions grounded in those perceptions (Eiser et al., 2012; Opdyke et al., 2022). Hence, adaptation research can acutely benefit from empirical investigations which seek to examine why some government actors proactively implement risk reduction strategies whilst others remain passive when faced by uncertainties (Abenir et al., 2022; Esteban & Edelenbos, 2023; Shah & Rana, 2023).

This research aimed to answer the following question: How do local governments make flood risk reduction decisions when confronted by uncertain climate futures? The main objectives of this research were to: (a) delineate the decision-making processes of adaptation governance archetypes, and (b) investigate how factors of uncertainty impede successful adaptation action. By evaluating how the distinctive interactions, attitudes, and behaviours of decision-makers contribute to protective action outcomes, this research offers new knowledge of the conditions to mobilise improved climate change adaptation in local government

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planning practices.

2. Background

Disaster risk governance is a key priority to improve community resilience and support climate change adaptation (Brower et al., 2014; Castaño-Rosa et al., 2022; Cutter et al., 2012; Hügel & Davies, 2024). However, decision-makers are frequently tasked to resolve often incongruent trade-offs which exist between urban development and disaster risk reduction processes, made more complex as a consequence of our changing climate. Our work responds to recent calls for climate pathway scenario exercises to establish local climate action plans (Khalid & Okitasari, 2023). Below we explore how disaster governance and uncertainty intersect and what we know about the way climate adaptation decisions unfold.

2.1. Disaster governance and uncertainty

The difficulties which arise in climate change scenarios coincide with Lipshitz and Strauss' (1997) sources of uncertainty in decision-making, which stipulate that uncertainties pertain to the *situation* at hand, the *choice* which must be made and the potential *outcomes* of such choice. Moure et al. (2023) extend Lipshitz and Strauss' classification to recognise the intrinsic relationship between uncertainty and time, as choices may be sensitive to different time frames, including *temporal* scales as a fourth source of uncertainty. Today, the critical typologies of decision-making uncertainty are widely recognised to fall into two distinct categories (Maier et al., 2016); (i) *epistemic uncertainties* result from inadequate or contingent knowledge regarding the causes and effects of a particular problem, and (ii) *aleatory uncertainties* describe the occurrence of doubt due to natural variability of future outcomes. However, in the context of strategic planning and policy, additional uncertainties may arise. Lidskog et al. (2005) recognises that (iii) *institutional uncertainties* develop as a consequence of perceived incongruences in decision-making or subsequent recommendations amongst relevant actors. Heazle (2010) also identifies that the absence of shared values and norms between decision-makers contribute to the development of (iv) *normative uncertainties* which result from attempting to prioritize a shared objective.

There is a consensus among scholars that uncertainties act to impinge upon effective decision-making as individuals tend to respond passively when faced by unknowns (Garschagen et al., 2021; Kiem et al., 2014; Maier et al., 2016; Moure et al., 2023; Winkler, 2016). For instance, decision-makers deliberately delay their actions by stalling or denying the presence of uncertainties (Moure et al., 2023). An example of inaction due to uncertainty is exemplified by Findlater et al. (2019) who found that residents in flood prone regions of South Africa were hesitant to adopt innovative farming practices to combat increased variability in rainfall patterns as they did not know whether climate conditions would remain constant or change. This is not an isolated case, rather the tendency to react passively in response to risk uncertainties has been continually reported to impede the adaptation actions of decision-makers globally (Siders & Pierce, 2021; M. S. Smith et al., 2011; Styczynski et al., 2014).

2.2. Response archetypes for climate change adaptation

Gallego and Tejero (2023) extend this consideration of behavioural inaction, acknowledging that communities are not faced with the binary decision to adapt or remain passive against disaster risk, rather these efforts reside on a continuum. The state of protective action on the continuum (i.e., passivity and responsiveness) can be understood by partitioning the attitudes, beliefs, and behaviours of actors into smaller homogeneous sub-groups or archetypes that reflect systematic differences in decision-making processes which contribute to varying outcomes of protective action (ibid). Archetype analysis has been increasingly employed to identify recurring patterns in the behavioural factors shaping social-ecological systems (Oberlack et al., 2019; Sietz et al., 2019). For example, behavioural characterisation has defined archetypical responses to bushfire threats (Strahan et al., 2018), natural resource scarcity (Frey, 2017), food security (Sietz et al., 2017) and climate change vulnerability (Vidal Merino et al., 2019). The human characteristics which distinguish decision-making tendencies between archetypes are dependent on external determinants (such as community dynamics i.e., socio-ecological context or access to information) and internal determinants (such as psychosocial factors i.e., self-efficacy or threat perception). Moure et al. (2023) put forward four overarching categories of uncertainty responses (depicted in Fig. 1), adapted from Lipshitz and Strauss' (1997) framework. *Acting* upon uncertainty is the recognition of future risks and taking action against them, and *reducing* uncertainty involves the seeking or sharing of information or knowledge (Moure et al., 2023). *Suppressing* uncertainty is the ignoring or denying of uncertainties, and *forestalling* uncertainty involves the deliberate delaying of actions and decisions under uncertainties (Ibid).

Such stratification is useful in understanding the differences in how people perceive and respond to threats (Strahan et al., 2018), where varied perceptions and motivations of archetypal groups can assist in developing social-ecological policy to increase the effectiveness and relevance of strategic programmes (Jäger et al., 2015), ultimately seeking to bridge the gap between global narratives and local realities. Individual risk perception has generally been found to be not based in physical exposure (Mayer et al., 2017), but rather is socially constructed within specific local contexts determined by culture, media (E. K. Smith & Mayer, 2018), political ideology and pressure (Patterson, 2021), and privilege (Birchall & Kehler, 2023; Hamilton et al., 2016; Marquart-Pyatt et al., 2014; Mayer et al., 2017). Birchall and Kehler (2023) found that when tasked with climate change adaptation, political and public actors avoided action through denial and discretion. While the systematic differences in decision-making processes have been documented for varying social-ecological systems, limited attempt has been made to develop archetypes which describe the tendencies for local governance to assume protective behaviours against disaster risk along the passivity-responsiveness continuum.

To rationalise why government authorities implement risk reduction strategies, decision-making processes can be systematically analysed under Rodgers' (1975) Protection Motivation Theory (PMT). This socio-psychological model stipulates two notions that provide reason for an individual's motivation to engage with maladaptive or protective behaviour: *threat* appraisal and *coping* appraisal (Kothe et al., 2019). Gumasing et al. (2022) describes threat appraisal to capture an individual's perception of hazard severity and perception of personal vulnerability to the effects of said hazard. It is suggested that a positive function exists between the probability of engaging with adaptation action and the magnitude of perceived risk (ibid). Coping appraisal is defined by an individual's assessment of their ability to manage a particular risk, influenced by self-efficacy, response efficacy and response cost (Villamor et al., 2023). If a respondent has confidence in the effectiveness of a protective action to manage risk (response efficacy) and assurance in their capability to implement the action (self-efficacy) at a feasible cost, PMT suggests a protective response will ensue (Xie et al., 2019).

To strengthen the implementation of disaster risk policy and

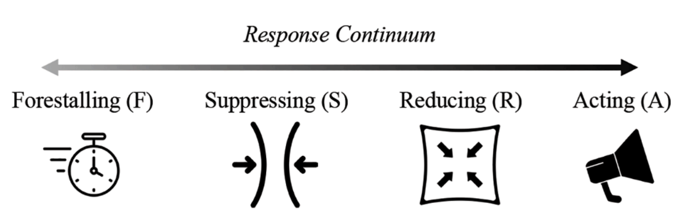


Fig. 1. Continuum of uncertainty responses.

participatory resilience (Mahajan et al., 2022), it is critical to develop a holistic understanding of the motivations of local governments, as well as identify the factors that impede or accelerate adaptation action. Active collaboration between government actors has been identified as a critical factor positively associated with higher policy outputs and more productive decision-making outcomes for disaster risk reduction and climate change adaptation (Kalesnikaite, 2019), including shared goals (Pregnolato et al., 2024). Such collaboration relies upon active dialogue and trust amongst stakeholders to increase information-sharing, generate social capital and drive innovative action to increase preparedness at the local level (Gaillard et al., 2013). Moallemi et al. (2023) extends this understanding, recognising the importance of diversified collaboration in the support of decision-making, to ensure solutions reflect the interests of all participants including elite and marginalised groups. Alternatively, an imbalanced representation of opinion may result in unsuccessful solutions due to the absence of support or legitimacy (Moallemi et al., 2023). Yet, diverse teams brought together in disaster risk management may differ in levels of familiarity and can be associated with varying objectives or priorities, threatening the degree to which activities are characterised by trust (Dietz et al., 2010).

2.3. Serious games as simulation tools

Serious games, games used for purposes other than entertainment, can be implemented as effective tools to interactively explore climate futures (Flood et al., 2018) and test strategies to real world problems in a safe, low stakes environment (Wu & Lee, 2015). While gaming has gained popularity as an educational mechanism for social learning (Ghodsvali et al., 2022; Mochizuki et al., 2021), it can also be used to simulate the social and technical complexities between climate change and disaster risk to understand stakeholders' reactions to different scenarios (Fleming et al., 2020; Gao et al., 2021). In the context of disaster risk reduction, serious games have been used as a method to explore planning alternatives, vulnerabilities, and hazard information in an interactive environment (Avendano-Uribe et al., 2022; Solinska-Nowak et al., 2018; Tsai et al., 2020; Villagra et al., 2023). Risk management decisions are often complex and contested between competing stakeholders, with serious games enabling participants to role play different decision-making contexts (Mendler de Suarez et al., 2012). Serious games can thus be a mechanism to examine climate and disaster management dilemmas and enable the realistic exploration of uncertainties.

The practice of utilising gaming scenarios to analyse behavioural tendencies and responses has been seen across multiple contexts including flood risk management (Liao et al., 2023; Toyoda & Tanwattana, 2023; Khoury et al., 2018), climate change adaptation (Abad et al., 2020; Hügel & Davies, 2024; Sillanpää et al., 2024), resilience (De Fino et al., 2023; Heinzlef et al., 2024; Villagra et al., 2023) and sustainability (Ghodsvali et al., 2022; Madani et al., 2017). For example, Abad et al. (2020) identified barriers to effective collaboration in climate change adaptation and disaster risk reduction policymaking through analysis of government officials' communication using a serious game coined "RAMSETE" (Risk Assessment Model Simulation for Emergency Training Exercise). Liao et al.'s (2023) Levee Dilemma game was used to examine social implications, communication and the influence of climate uncertainty on players' decision-making in flood management scenarios, uncovering the importance of civic engagement in policy and public education on climate uncertainty for improved risk balancing outcomes. As these examples attest, serious games offer a means to test and understand communication behaviours and decision-making processes of government actors when faced by uncertainties.

3. Methods

This research developed a serious game to examine collective flood risk decision-making in local governance under climate change uncertainties. We provide an overview of the game development first, before describing gaming workshops run in the Municipality of Carigara, located in the province of Leyte in the Philippines. These workshops were used to cluster recurring strategies that underpin local governance, flood risk management and adaptation decision-making into distinct archetypes.

3.1. Phase 1: serious game development

We conducted initial scoping work in Carigara to benchmark climate change adaptation understanding within the local government. This step was also critical to embed local knowledge, civil beliefs, and real-world parameters in the Philippines into our game design to ensure relevance and appropriateness (Hadlos et al., 2022; Sanogo et al., 2017; Sautier et al., 2017). Carigara was chosen as the case site for this research as the low-lying coastal settlements of the municipality make this region particularly vulnerable to the impacts of hydrological hazards and climate change. The province of Leyte has seen some of the highest disaster impacts nationally across the Philippines (Gray et al., 2022; Lloyd et al., 2022). It was our goal to target government leaders at the municipal and community level as this is where significant risk governance takes place in the Philippines (Alcayna et al., 2016; Blanco, 2015).

Fourteen semi-structured key information interviews (KIIs) and three focus group discussions (FGDs) were conducted with representatives of relevant local government unit (LGU) offices and other key community stakeholders. Local government offices included the Municipal Disaster Risk Reduction and Management Office (MDRRMO), the Municipal Planning and Development Office (MPDO), the Municipal Health Office (MHO), and Municipal Agriculture Office (MAO). Other stakeholder groups involved included the largest local farming association, barangay captains (community leaders of the smallest administrative division in the Philippines), and local sangguniang kabataans (SKs), or youth associations. We focused on three themes: (1) how disaster risk assessments and climate change adaptation strategies are currently implemented, (2) knowledge flows between government and community stakeholders, and (3) local preferences for gameplay. For example, we asked: "*How do you think climate change will impact your LGU?*" and *"What are the barriers to implementing climate change policies at the LGU level?"* Additionally, to capture game understanding and norms, example questions included, *"What were your favourite childhood games? Or do you play any computer or board games?"* Interviews were conducted in a mix of English and Waray – the local language – recorded, translated (where required), and transcribed.

We also involved 19 participants of the FGDs and KIIs in a game workshop to investigate local gaming preferences and identify mechanisms of gameplay which promoted cooperative decision-making. We invited participants to play traditional Filipino games, such as *Sungka*, a two-player turn-based board game wherein the players compete to obtain more stones (Benavidez, 2023). We also used other popular games, including *Catan* and *Pandemic.* The games selected for this session were intentionally varied to observe how local participants engaged with different game formats. Fieldnotes were recorded by a research team member for each group, noting how participants engaged with game elements. We then qualitatively analysed and grouped themes across both our observations, KIIs, and FGDs, seeking to group relevant themes to inform the second stage of game design.

3.1.1. Game design

Drawing on lessons from the first phase of data collection to contextualise gaming elements, we aimed to increase the credibility of gameplay by triggering emotional pathways of players (Caserman et al., 2020; Razali et al., 2022). We targeted character, narrative, setting, aesthetic, and game mode elements to embed Filipino themes and motifs. For example, game *characters* were chosen to reflect realistic roles such as a barangay captain (local leaders in the Philippines). Additionally, activity cards were used to contextualize the *game narrative* to reflect common Filipino traditions such as fiestas or karaoke. At the same time, we also made these elements easily substitutable so that the game could be adapted for different national contexts. During development, the game was tested by stakeholders including members of our research team and local government representatives from the Municipal Disaster Risk Reduction Management Office in Carigara. Feedback from these sessions was applied to iteratively improve the mechanics of the game.

3.1.2. Game overview

The objective of our game is for players to work together to make their community resilient against flooding. We provide a summary of the key game elements below, including the procedure of play, the implementation of adaptation actions, the occurrence and impact of flood events, the climate tracker, and the game outcomes. The main game features are depicted in Fig. 2. The full game materials are available in Opdyke et al. (2024) and are free to download here: https://doi.org/10.25910/0vev-ab45.

3.1.2.1. Procedure of play. There are three rounds of gameplay. A character's turn involves (1) picking up and playing an action card, (2) moving their pawn up to four consecutive locations on the gameboard, (3) purchasing an adaptation strategy if the player has sufficient currency to do so, (4) giving currency to other players if they wish to do so, and to finish the turn (5) collecting two currency cards from the central bank.

3.1.2.2. Game board & location tiles. The game board is comprised of location tiles representative of community infrastructure, such as a barangay hall, an LGU office or a school. Each location has an assigned number of starting resilience tokens (RTs) to represent its vulnerability to flood events. A location's resilience can be increased by playing adaptation actions, or decreased when a flood event occurs.

3.1.2.3. Adaptation actions. To increase a location's resilience, players can purchase an adaptation strategy to implement on their turn using their currency – which include both Philippine pesos and power. The former of these represents a monetary currency and the latter a form of social capital. The list of climate change adaptation strategies used was selected from the Philippine Atmospheric, Geophysical and Astronomical Services Administration of the Department of Science and Technology (DOST-PAGASA et al., 2020). Information regarding each adaptation strategy and its associated cost are provided to players on their character menus, with these tailored to different player roles. Some adaptation strategies cost more but have corresponding higher impact – signified by the number of resilience tokens (RTs) that are added to a location. When a location obtains eight resilience tokens, it has achieved a state of full resilience and cannot be impacted by future flood events.

3.1.2.4. Flood events. Shuffled throughout the action card deck are flood hazards, naming zones of the community subject to the potential impacts of a flooding event. If a flood hazard card is pulled, the severity of the flood is determined by rolling the game dice, and players must remove the corresponding number of resilience tokens from the locations in the affected zone(s).

3.1.2.5. Climate tracker. The number of dice rolled for a flood event can change in gameplay. In the near term, climate risks are well known, while the extent of future impacts experienced by the changing climate is uncertain. Therefore, the game is moderated by a *climate tracker,* to recognise plausible climate resilient development pathways (CRDPs) which we adapted from the Intergovernmental Panel on Climate Change (IPCC, 2023). CRDPs are trajectories in time which navigate near-term trends in climate adaptation and mitigation measures, leading to specific climate futures (Haasnoot et al., 2013). The uncertainty associated with achieving specific pathways and climate outcomes challenges policymakers as the magnitude of impacts are unknown (IPCC, 2023). To represent this uncertainty, players roll the number of dice specified by the climate tracker when a flood event occurs.

3.1.2.6. Game outcomes. The result of the game is determined by (1) the number of locations which are made fully resilient versus (2) the number of locations which are destroyed. This metric provides feedback to players through the *resilience tracker* which is adjusted as the game unfolds. Short epilogue descriptions are provided to players for each of the four levels on the resilience tracker. Players have excelled in the game when the resilience tracker resides on green and have failed in the game when the resilience tracker resides on red, with corresponding narratives.

Fig. 2. Game elements and board setup.

3.2. Phase 2: game data collection and analysis

A total of eleven gaming sessions, involving 62 players, were conducted. Participants were recruited from the same six local government departments and community organisations identified during the first phase, selected due to their decision-making relevance and capacity for flood risk reduction decision-making within the LGU. Participants included both senior and junior departmental staff with varying levels of expertise. Gaming rounds were structured with both homogeneous and heterogeneous teams of six to seven players. Teams were classified to be homogeneous if participants originated from the same department and heterogeneous if participants originated from mixed departments. During each gaming session three forms of primary data were collected to examine decision-making tendencies: in-game observations, pre- and post-game surveys, and field notes.

In-game observations were recorded to track the actions of each player as the game progressed. This included the number of resilience tokens implemented per turn through adaptation strategies, the locations impacted by flood events, and the type of adaptation actions implemented. Surveys were administered before and after gameplay using either a paper hard copy or using Qualtrics – a digital survey platform – on a laptop or phone. The pre-game questionnaire was used to define player profiles, assess player knowledge of flood hazards, and examine player confidence in personal understanding of climate change impacts. For example, participants were asked to express their level of agreement with various statements on a 5-point Likert scale, "*I feel comfortable prioritising resources and time for climate change adaptation.*" The post-game questionnaire was used to gather feedback and investigate how players managed the uncertainties of gameplay. For example, players were asked "*What was the largest challenge to winning the game?*" and "*How did the game impact your understanding of the uncertainty of climate change impacts?*". Field notes were also taken by an observer to document remarks and strategies adopted by players during gameplay, such as the extent and type of collaboration displayed in each gaming session.

3.2.1. Archetype analysis

To synthesise recurring strategies from the gaming sessions, we applied archetype analysis through content analysis and clustering to identify 'thick' descriptions of casual factor configurations (Sietz et al., 2019). Five critical determinants emerged to distinguish the gaming sessions. These determinants included (1) team composition, (2) the level of collective efficacy, (3) the extent and mode of collaboration in gameplay (4) location targeting preferences, and (5) adaptation choices. From literature, we knew that team composition (Moallemi et al., 2023; Godschalk, 2003), collective efficacy (Bostrom et al., 2019; Xie et al., 2019) and collaboration (Dwirahmadi et al., 2019; Kalesnikaite, 2019) were going to be important but did not know how they would manifest and we thus took an inductive approach to identity patterns within these determinants. The final two determinants – location targeting preferences and adaptation choices – emerged as significant behavioural dimensions of decision-making from observations of gameplay.

Group composition was introduced to classify gaming sessions according to the backgrounds of participants. Diverse teams may differ in levels of familiarity which may threaten the degree to which actors trust, communicate and navigate challenges of gameplay. However, teams composed of diverse organisational representatives may integrate their respective contributions in complementary ways (Moallemi et al., 2023). To investigate these dynamics, teams were classified to be *homogenous* where all players were from the same organisation or department, and mixed groups were labelled as *heterogeneous*.

Collaboration captured the extent and mode of cooperation in each gaming session. The following three distinct modes of interaction and negotiation were emergent from gameplay. Firstly, *ad-hoc collaboration* was assigned to describe games with limited cooperation between actors. For example, sessions were assigned to this category if actors were conversational but avoided deliberation, rather conserving discussion for emphatic celebrations or commentary of gameplay. Secondly, games with strong *hierarchical* structures described sessions that contained players with dominating personalities whose influence governed. Finally, *network-orientated* collaboration emerged from games with relatively uniform power managed equally between actors. These games contained players who facilitated knowledge and perspective sharing. Each game was assigned to a class of collaborative action on account of the direction and exchange of information observed in gameplay by a research team member and validated using post-game discussions with participants.

Collective efficacy summarised the level of cumulative confidence exhibited by individuals in each gaming session. When a respondent has confidence in the effectiveness of an adaptive action to manage risk (response efficacy) and assurance in their capability to implement the action (self-efficacy), theories of protective motivation suggest a response will ensue (Bostrom et al., 2019; Xie et al., 2019). Therefore, this characterising feature of gameplay pertains to willingness to engage in adaptive action for risk reduction. Accordingly, the pre-game questionnaire was used to evaluate collective response efficacy using an aggregate of individual questionnaire scores to form a wholistic rating of efficacy per gaming session. The following statements, answered using a Likert scale from strongly disagree to strongly agree, were used to determine *collective efficacy*:

- Disasters are a product of our development choices.
- I understand why some areas are more impacted by floods than others.
- I understand how climate change will impact flood risk.
- I understand the differences between the cause of climate change and planning for its impacts.
- I feel comfortable prioritising resources and time for climate change adaptation.
- I acknowledge that compromise/negotiation between stakeholders is important to achieve climate adaptation goals.
- Climate change impacts are certain.

Likert scale answers were converted to values and then standardised. We ran a Cronbach's Alpha test which confirmed a high level of internal consistency (0.823) among the seven questions. Games were then stratified using standard deviation as a measure of dispersion such that three groups of *collective efficacy* – low, moderate, and high – were defined on account of a game's proximity to the mean efficacy rating. For instance, collective efficacy ratings falling more than one standard deviation below the mean were classified as low, those falling within one standard deviation either side of the mean were considered medium and those more than one standard deviation above the mean were classified as high.

Location preferences were categorised to understand the prioritisation of resilience building, where it occurred, and the timing with which it ensued in gameplay. Locations that were targeted for adaptation strategies were grouped into *low, medium,* or *high* resilience locations based on their assigned number of starting resilience tokens. Low resilience locations started with two or three resilience tokens, medium resilience locations started with four resilience tokens, and high resilience locations, started with five or six resilience tokens. These break points were determined to ensure there was as close to an even split between the classifications as possible. Using recorded game observations, the number of low, medium, or high resilience locations targeted in each round were tallied. Heat maps were generated to illustrate the frequency with which each group of locations were targeted in each round of each game.

Adaptation preferences captured the types of adaptation actions used in gameplay and the timeliness of those investment decisions. Three typologies of adaptation were classified based on the impact of a selected adaptation strategy, quantified by resilience tokens, and the cost to purchase. The typologies of adaptation were defined to be *high impact, high cost* (HIHC) strategies which came at a cost of five or more currency cards to implement and offered five or more resilience tokens in benefit. *Low impact, low cost* (LILC) strategies were defined as between two and four currency cards to implement and offering two and four resilience tokens. *No impact* (NI) strategies required a contribution of one currency card or no currency contribution to implement one resilience token or no resilience tokens. Trends in the implementation of adaption strategies were visualised using heat maps to identify the type of adaption strategies players preferred to implement during different rounds of gameplay, giving insight into the timeliness of investment decisions.

To assemble these components into archetypes of decision-making, we used grounded theory – the identification of repeatedly occurring themes and subsequent analysis to uncover underlying explanations and associated groupings (Moser et al., 2019; Glaser & Strauss, 2017; Walsh et al., 2015). This approach is consistent with contemporary archetype analysis (Eisenack et al., 2019, 2021). After games were categorised into determinants, trends across these classifications were identified by iterative and recursive grouping of similar traits. Causal explanations of these archetypes were tested for coherency and conformity with other game sessions. This iterative theory building process established consistency amongst the archetypes.

3.2.2. Game analysis

To determine how the archetypical choices of decision-makers impacted their performance in gameplay, metrics for assessing the outcomes of gaming sessions were established to be (1) the number of location tiles which were brought to full resilience (measured as 8 resilience tokens) and (2) the number of location tiles which were *destroyed* (lost all of their resilience tokens). Ultimately, we were interested in how teams maximised the number of locations made fully resilient, and the number of locations destroyed was reduced. *Situational, temporal, choice* and *outcome* uncertainties were analysed through when, where, and how participants were able to build resilience. We qualitatively coded field notes of our game observations and open-ended responses provided in post-game surveys to identify themes relating to each type of uncertainty and disaggregated these by the above identified decision archetypes. For example, we deductively identified where uncertainty in gameplay was being reduced (e.g., available resources) and the strategies mobilised (e.g., resource sharing).

4. Results and discussion

In this section we present three distinct archetypes of collective adaptation decision-making that emerged. We will first outline the characteristic traits which differentiate archetypical governance cohorts, followed by an exploration of the prioritisation and trade-off decisions made by each archetype, and the impact climate uncertainty had on those choices. The implications for policy, planning, and practice will then be discussed. The determinants for each game session are summarised in Table 1, including their assigned archetype.

4.1. Hierarchical alliances

The *Hierarchical Alliances* (HA) archetype was observed in 18 % of gaming sessions. This archetype characterised teams who relied on the leadership of few elite actors to direct decision-making. These individuals tended to be decisive, projecting authority and taking command of the entire group, without providing a platform for others to suggest strategies or ideas. Such behaviour was apparent in teams originating from homogeneous government departments who exhibited low to moderate levels of collective confidence in their ability to engage in adaptive action for disaster risk reduction. Therefore, when faced with uncertain climate scenarios, decision-makers were comfortable conforming to the guidance of a familiar powerful actor within the group. Location targeting preferences under this archetype tended to be for low resilience locations for all three rounds of the game. Throughout gameplay decision-makers demonstrated no preference for a particular class of adaption investment which led to no uniform strategy in the use of resources or prioritisation of time, as depicted in Fig. 3, which illustrates the initial ambiguity of decision-makers who chose to passively execute no impact (NI) or low impact, low cost (LILC) adaptation strategies. However, when directed by authoritative members of their team nearing the conclusion of gameplay, high impact, high cost (HIHC) strategies were chosen for implementation.

4.2. Passive enthusiasts

The *Passive Enthusiasts* (PE) archetype was observed in 45 % of gaming sessions. This archetype was characterised by teams who engaged in ad-hoc collaboration. The passive tendency accompanied teams who exhibited low levels of collective confidence in their ability to engage in adaptive action. This low efficacy often led to indecisiveness, for example, one participant remarked that the largest challenge to successful game outcomes was "coming up with strategies". Preference was low impact, low cost (LILC) or no impact (NI) adaptation strategies to marginally reinforce vulnerable assets without obligating resources towards the implementation of high impact, high cost (HIHC) strategies, which were avoided. The consistent implementation of LILC and NI strategies across all rounds of gameplay is depicted in Fig. 3. Similarly, groups appeared to have no apparent preference for targeting locations, likely due to a lack of risk knowledge and low confidence leading to indecisiveness.

4.3. Deliberative strategists

The *Deliberative Strategists* (DS) archetype was observed in 36 % of gaming sessions. This archetype was characterised by network-orientated collaboration where power was managed equally among

Table 1
Archetype determinants and distribution of location and adaptation preferences.

Archetype	Game Sessions	Group Composition	Collaboration	Collective Efficacy	Location Preference		Adaptation Preference	
Hierarchical Alliances (HA)	G1, G8	Homogeneous	Hierarchical	Moderate	Low	50%	NI	48%
					Medium	28%	LILC	40%
					High	22%	HIHC	13%
Passive Enthusiasts (PE)	G2, G3, G5, G7, G11	Homogeneous or Heterogeneous	Ad-hoc	Low to Moderate	Low	38%	NI	36%
					Medium	34%	LILC	64%
					High	28%	HIHC	0%
Deliberative Strategists (DS)	G4, G6, G9, G10	Heterogeneous	Network-orientated	Moderate to High	Low	30%	NI	28%
					Medium	38%	LILC	62%
					High	32%	HIHC	9%

NI – no impact; LILC – low impact, low cost; HIHC – high impact, high cost.

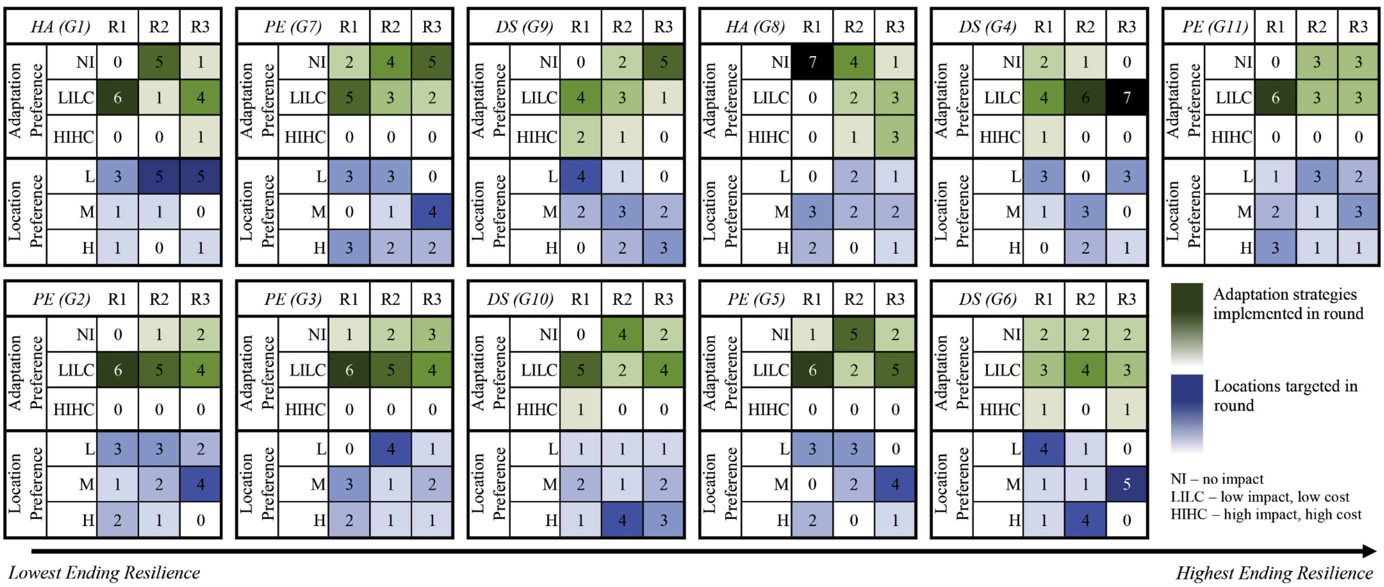


Fig. 3. Heatmaps of Adaptation Strategy Choices and Targeted Locations.

decision-makers. Collective action governed this archetype, with perspectives acknowledged and considered before proceeding with decisions. For example, one participant from The *Deliberative Strategists* commented that to "protect the community [we must] hold on together." A core targeting strategy for this archetype was a preference for low resilience locations early in the game before prioritising medium to high resilience locations in the first and second rounds. Additionally, the strategic decisions of participants were deliberated to identify common ground through negotiation, creating considered risk management pathways, while also embracing a plurality of perspectives. This archetype placed importance on obligating resources towards the implementation of high impact, high cost (HIHC) strategies at the outset of gameplay to minimise disaster risk, as evidence in Fig. 3. Low impact, low cost (LILC) and no impact (NI) adaptation actions were employed to supplement the resilience of vulnerable assets at the conclusion of gameplay. These patterns originated from heterogeneous government departments who exhibited moderate to high levels of collective confidence in their ability to engage in adaptive action. While decision-makers exhibited assurance in the effectiveness of their proposed strategies to manage disaster risk, discussions were unhurried, and policies were employed deliberately.

4.4. Game outcomes

Game outcomes were used as markers for the "success" of each game session in managing flood risks. The number of locations destroyed or made fully resilient, and the extent of flood impacts are outlined in Table 2, including the mean values for each archetype. All games started with 61 resilience tokens (RTs) and the flood severity ranged from 0 to 4, across the affected zones, for the four flood occurrences.

The *Hierarchical Alliances* and the *Passive Enthusiasts* had a similar number of locations destroyed (HA = 4.5, PE = 4.8) and locations made fully resilient (HA = 10, PE = 9.6). When considering the proportion of destroyed locations to resilient locations, differences became apparent in the performance of each archetype. Despite having the fewest fully resilient locations (DS = 8), the *Deliberative Strategists* also had the fewest destroyed locations in comparison to the other archetypes (DS = 3), with the highest ratio of fully resilient to destroyed locations. This suggests that the *Deliberative Strategists* were more effective at risk balancing than the other archetypes. For every one location destroyed, 2.25 locations were made resilient for the *Hierarchical Alliances*, 2.56 for the *Passive Enthusiasts* and 3.33 for the *Deliberative Strategists*. The *Deliberative Strategists* lost the least locations and proportionally made the most locations resilient. Other studies relating to decision-making of public

Table 2
Summary of game outcomes by session.

Game Session	Archetype	Destroyed Locations	Resilient Locations	Ratio of Resilient to Destroyed	RTs Added	RTs Lost	Final RTs	Mean Flood Severity
G1	HA	5	10	2.00	44	39	66	1.2
G8	HA	4	10	2.50	65	32	94	1.4
G11	PE	2	10	5.00	54	14	101	1.6
G3	PE	3	9	3.00	60	36	85	1.4
G2	PE	6	10	1.67	46	33	74	1.6
G5	PE	5	10	2.00	64	31	94	1.8
G7	PE	8	9	1.13	52	35	78	2.4
G6	DS	2	11	5.50	54	15	100	1.0
G4	DS	1	4	4.00	63	25	99	1.2
G10	DS	4	8	2.00	63	39	85	1.4
G9	DS	5	9	1.80	57	33	85	1.6
Mean Values	HA	4.5	10.0	2.25	54.50	35.50	80.00	1.30
	PE	4.8	9.6	2.56	55.20	29.80	86.40	1.76
	DS	3.0	8.0	3.33	59.25	28.00	92.25	1.30
	All	4.1	9.1	2.78	56.55	30.18	87.36	1.51

HA – Hierarchical Alliances (red); PE – Passive Enthusiasts (yellow); DS – Deliberative Strategists (blue).

organisations and climate adaptation have found similar levels of institutional logics and performance (Zhang & Welch, 2023). In particular, this aligns with growing scholarship pointing to the importance of participatory governance structures and the 'redistribution of expertise' (Hügel & Davies, 2020).

We also observed differences across archetypes in *when* they built resilience. The cumulative resilience tokens for each game, which track the number of resilience tokens on the board for every turn, are illustrated in Fig. 4, disaggregated by archetype. In the first round, the *Deliberative Strategists* tended to build the most resilience, followed by

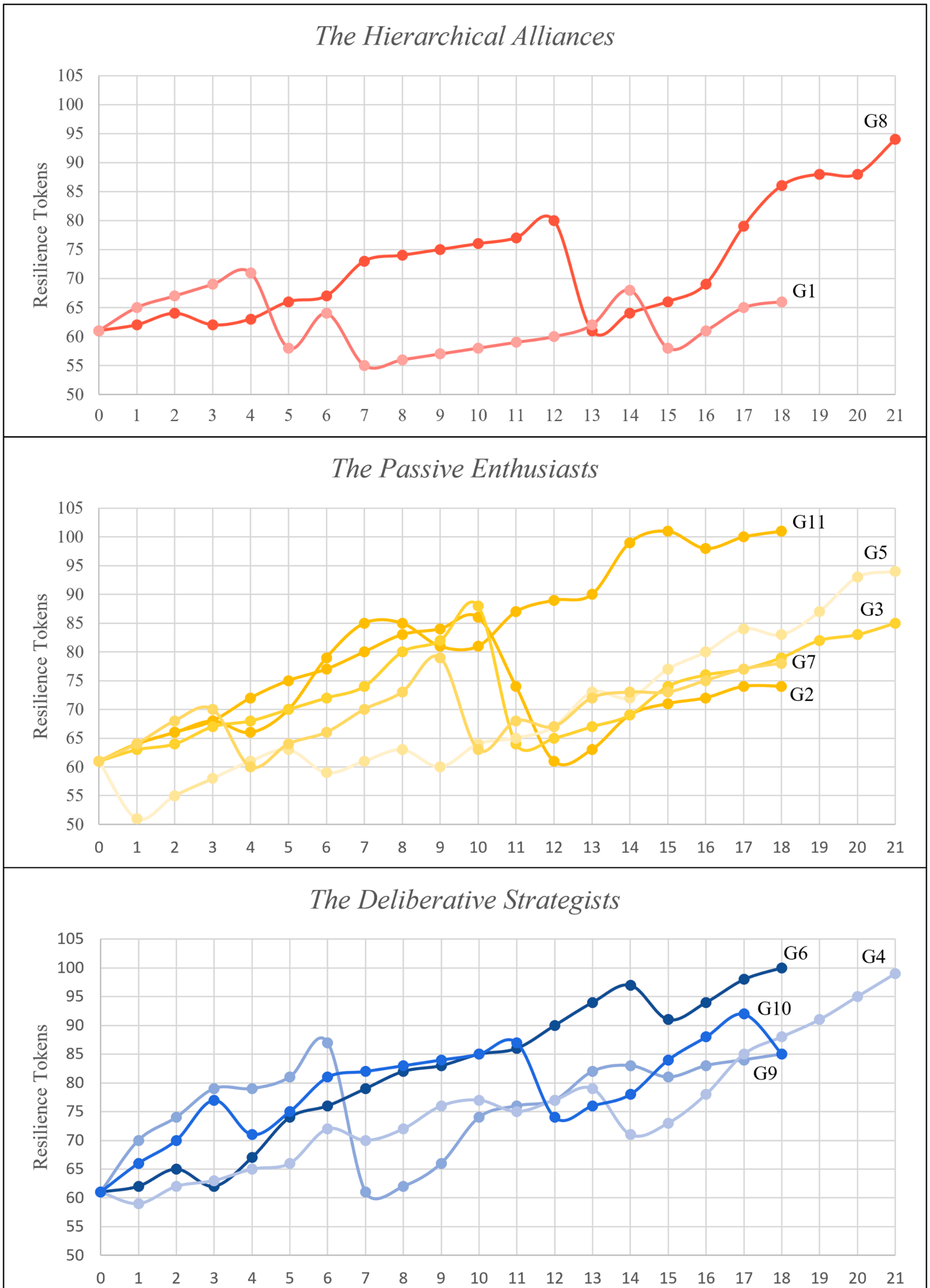


Fig. 4. Game pathways depicted by total resilience across rounds.

the *Passive Enthusiasts*, with the *Hierarchical Alliances* moving at a slower pace, as seen by the gradients for the first 6–7 turns of each game. Our results align with scholarship in organisational theory which shows how small wins can be amplified for sensemaking (Termeer et al., 2017). While studies have called for incremental, transformative, and transformational adaptation (Allen et al., 2023; Filho et al., 2023), our findings point to the growing importance to link these (Heijden, 2023).

4.5. Understanding decision-making under uncertainty

We identified four sources of uncertainty that arose (or were imposed) in our study: *situational, choice, outcome*, and *temporal* (Lipshitz & Strauss, 1997; Moure et al., 2023). Uncertainty is faced either passively, for example by ignoring the problem, or actively, such as establishing safeguards (i.e., building resilience in the game) (Bijlsma et al., 2011), and be classified using Moure et al.'s (2023) four overarching categories of uncertainty responses, adapted from Lipshitz and Strauss' (1997) framework – *acting upon* uncertainty, *reducing* uncertainty, *suppressing* uncertainty, and *forestalling* uncertainty. Each archetype's responses to the different sources of uncertainty can be categorised along Gallego and Tejero's (2023) Response Continuum, which describes the spanning tendencies of individuals ranging from inaction, compliancy, and non-optimisation of mitigation strategies to assertive behaviours that seek to build resilience and minimise exposure to disaster risk (Gallego & Tejero, 2023). We suggest extending the Response Continuum to include proactive behaviours (i.e., ranging from passive to reactive to proactive). The categorisation of each archetype's uncertainty responses and their position along the Response Continuum are illustrated in Fig. 5. The absence of uncertainty responses for some archetypes, particularly the *Passive Enthusiasts,* should not be conflated with passive uncertainty responses (e.g., forestalling and supressing), but rather a lack of cohesive reaction.

4.5.1. Situational uncertainty

The *situation* presented was unique to each game, with participants put into different roles, limited information available on how climate change would unfold in the game, and a lack of guidance on what approach to take to manage flood risks. These, and other conditions, created ambiguity in how to act. We saw two primary responses to situational uncertainty which included: (1) resource sharing and (2) coordination.

Game play reflected uncertainty over resources (e.g. financial and institutional capital), which often limits CCA and DRR action (Dwirahmadi et al., 2019). One participant noted that inadequate resources were "*limiting the players' [ability to make] moves*." We saw the *Deliberative Strategist* groups strategically sharing currency (in 75 % of games) to *reduce* situational uncertainty and stabilise their access to resources. This gave higher certainty over the resources each player would have at their disposal and expanded the menu of options they could then implement. We observed limited to no sharing of currency in any games of the *Hierarchical Alliance* or the *Passive Enthusiast* archetypes. The second response we observed was coordination, which saw groups allocate tasks and formulate strategy to reduce unknowns of the situation. As an example of how this was employed by the *Hierarchical Alliance* archetype, in session G8, the group *acted* upon uncertainty through coordinated efforts to save currency early by all players using only the no-cost adaptation strategy ('volunteering'), thus freeing future resources to target higher impact adaptation strategies. This strategy reduced uncertainty in how other players would act once agreed. This style of coordination was driven by the group's hierarchy, but we saw similar levels of coordination mobilised by the *Deliberative Strategist* groups.

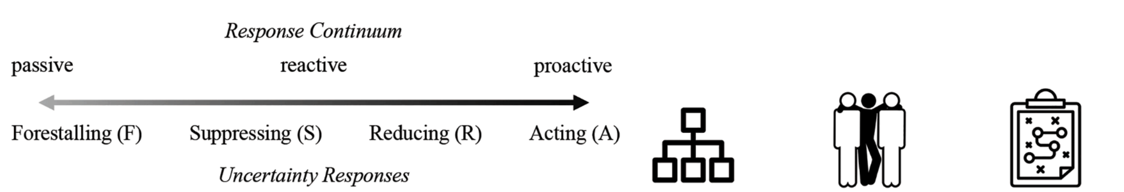
4.5.2. Temporal uncertainty

Temporal uncertainty manifested through the random occurrence of flood events, challenging decision-making regarding *when* to build resilience. It meant decision-makers needed to make assumptions about the future state of their community, such as when and where climate change impacts might manifest, to make planning and implementation decisions. One participant stated, *"The largest challenge to winning the game is the inability to determine when a disaster will happen." Temporal* uncertainty was deliberately manufactured into the game mechanics, however, was responded to differently by each archetype through their adaptation investments, location targeting preferences and the timing of these decisions. This response to temporal uncertainty was broadly categorised as early action.

The *Deliberative Strategists acted* upon temporal uncertainty by targeting low resilience locations early in the game to minimise their risk of becoming destroyed later, then moving on to higher resilience locations. These decision-makers found value in targeting their resources towards locations early, rather than later. The *Hierarchical Alliances suppressed* uncertainty by steadily focusing on low to medium assets throughout all three rounds, and only using high impact adaptation strategies late in the game. The *Passive Enthusiasts forestalled* uncertainty by exhibiting no preference for location targeting and consistently implementing low impact adaptation strategies.

4.5.3. Choice uncertainty

Decision-making regarding *how* to build resilience, and *where,* was defined by *choice* uncertainty – selecting the most suitable option –



Uncertainty Type	Uncertainty Response	Hierarchical Alliances	Passive Enthusiasts	Deliberative Strategists
Situational	Resource Sharing	–	–	R
	Coordination	A	–	A
Temporal	Early Action	S	F	A
Choice	Mobilising Values	R	R/S	R/S
	Transferring Accountability	S	–	–
Outcome	Risk Balancing	R	–	A

Fig. 5. Adaptation archetypes and uncertainty responses.

forcing participants to make trade-off and prioritisation decisions. Trade-off decisions involve diminishing a desirable outcome in return for gaining benefits of another (Tuhkanen et al., 2018). These involved time (short- vs. long-term planning), resource (allocation of currency), and spatial (prioritisation of locations) considerations. For example, players were required to weigh up how to allocate limited resources for adaptation strategies among competing demands, with one participant stating, *"I think the biggest challenge is knowing how many resilience tokens to play on each location, should we save the farm or the evacuation centre?"* Trade-offs in decision-making were not only restricted to the prioritisation of resources, but participants were also required to manage the opportunity costs of their decisions. We saw the archetypes employ two responses to choice uncertainty: (1) mobilising values and (2) transferring accountability.

The prioritisation of locations based on perceived value to participants, other team members, and their community was one of the ways all participants responded to *reduce* choice uncertainty. For example, critical infrastructure (e.g., evacuation centre, municipal offices, and medical centre) were targeted in 91 % of games, indicating the perceived importance of these locations by groups in disaster scenarios. Resilience was built on schools in every single game, suggesting its importance within the community. On the other hand, less critical community assets (e.g., the basketball court and the market) were only targeted by approximately half of the games (55 % and 45 % respectively), implying that participants perceived these assets to be more expendable. We also saw specific groups targeting assets of value to them. For example, in sessions G4 (*Deliberative Strategists*) and G5 (*Passive Enthusiasts*), comprised of participants from the local farmers association and members of the agricultural office, the farm locations were made a priority for building resilience. By prioritising based on the importance of the farms to themselves, these participants *suppressed* uncertainty by focusing purely on the farms and overlooking resilience building for the other locations. In the case of the *Hierarchical Alliance* groups, we also observed a second uncertainty response which saw individuals transferring accountability to leaders within the group. By deferring choices to dominating personalities, the majority of members in these groups *suppressed* their choice uncertainty. This centralised who had to cope with the uncertainty for choices.

4.5.4. Outcome uncertainty

Uncertainties surrounding the effectiveness of adaptation strategies and their success in reducing current and future climate risks have been identified as one of the most significant barriers to decision-making in literature (Moure et al., 2023; UNEP, 2022). Despite the various strategies employed by each archetype to combat *situational, temporal*, and *choice* uncertainties, the *outcomes* of such decisions, and climate change impacts, remained uncertain. The main response we observed was risk balancing – seen through the targeting of low resilience locations over with already high resilience. We saw the *Deliberative Strategist* groups prioritise cheaper, lower resilience adaptations strategies. This exhibition of risk balancing between current and future flood impacts *acted* upon uncertainties by ensuring they distributed resources to cover future resilience building whilst maintaining current needs. In contrast, the *Hierarchical Alliance* groups focused purely on saving for future flood events to *reduce* overall outcome uncertainty in the long term, but at the expense of short-term impacts.

Differences in the outcome uncertainty responses between the archetypes become further apparent when examining their reactions to the largest flood event of each game. For example, G9 (*Deliberative Strategists*) experienced the largest single impact from a flood in all games played, losing 32 resilience tokens in the first round. Yet, the group rebounded, with a steep increase in resilience tokens added, implementing 22 tokens in the six turns immediately following that flood event. In session G2 (*Passive Enthusiasts*) which experienced back-to-back flood events, losing the same amount of resilience tokens, the group only added 17 tokens in the subsequent in the same duration, showing a more passive approach. In session G8 (*Hierarchical Alliances*), on the other hand, the group responded to their most impactful flood event (24 resilience tokens lost) by building 34 resilience tokens worth of adaptation strategies in the same number of turns.

4.6. Implications for policy, planning, and practice

The three decision-making archetypes developed in this research describe strategies employed by decision-makers for climate (in)action. Lessons globally show us how archetypes might inform the development and improvement of policy and practice (Jäger et al., 2015; Strahan et al., 2018). Our results hold importance for coastal communities in the Philippines who are likely to bear the brunt climate change impacts. In particular, our results advance theory of anticipatory climate governance (Muiderman et al., 2020).

While vertical climate change knowledge networks are strong in the Philippines, the mechanisms for horizontal, local cross-departmental collaboration are lagging (Cuevas, 2018). Local government units are hierarchical organisations which are constrained by the institutions in which they are embedded, but our results point to how this might be seen as more than just a barrier. These hierarchies might be inadequate when balancing short-term versus long-term planning decisions (*temporal*) and how to choose where to make investments (*choice*) in communities, but these organisational structures are well placed to tackle *situational* planning. We've seen examples of this capacity manifest at the intersection of disaster risk reduction and climate change adaptation in the Philippines (de Leon & Pittock, 2017; Pulhin et al., 2010). To advance this process, mayoral offices at the local level might take a more active role in mobilising their influence to bring departments together to better coordinate resources for climate adaptation. This enabling role for resource and knowledge sharing would counter this recurring gap identified in adaptation governance in the Philippines and other international contexts (Measham et al., 2011).

However, our results raise questions regarding the status quo of governance structures to plan for the temporal and choice uncertainties in climate change adaptation. Climate and Disaster Risk Assessments (CDRAs) and Comprehensive Land Use Plans (CLUPs) – which are guiding local planning efforts across the Philippines – are relatively fixed instruments, lacking the ability to keep pace with rapidly evolving data and information on climate change. Governing this risk in practice is currently seen as a one-time, momentous exercise, but as our gaming sessions show, effective groups are those which can employ incremental and iterative adaptation strategies as they learn. To support this process, local planning departments should grow to see themselves not as institutions delivering technical services, but rather facilitators of co-production of climate risk knowledge (Hermesse et al., 2018). Such an approach is broadly relevant to connect global narratives and local realities (Balvanera et al., 2017; Oberlack et al., 2019).

Lastly, there is the question of how we avoid the trap of falling into passive planning. Previous literature has identified that awareness and knowledge as important to enable effective resilience building (Dwirahmadi et al., 2019; Gao et al., 2021; Lebel et al., 2016). We similarly found collective efficacy built upon disaster risk and climate knowledge led to higher performing teams. This points to a need to focus on expanding training among local governments to build knowledge of potential climate change impacts and principles to respond (Bollettino et al., 2020; Grefalda et al., 2020). It is not sufficient for this to be delivered within one sector – such as to local Disaster Risk Reduction and Management Offices – as currently conceptualised, but rather there is a need to expand and mainstream these efforts.

4.7. Limitations

The uncertainty of flood events within the game meant that some games experienced higher severity flood events than others. Although this was intentionally manufactured into the game mechanics to simulate real uncertainties, the random nature of dice rolls led to differences in flood impacts. It is possible that the timing and size impacts may have subsequently impacted group decisions. The number of flood cards and the zones in which they occurred were however consistent across all games. Finally, the serious game and data was developed within a specific knowledge context bounded to a single municipality in the Philippines, opening the question of whether our conclusions can be meaningful across other contexts. Based on the demographic characteristics of our case site, we believe that the findings do hold relevance for other coastal urban communities across the Philippines. Our approach was one of *theory building* – not testing – and believe there is room to more closely examine if the archetypes identified in this study hold true for other communities.

5. Conclusion

The overarching objective of this research was to understand how local governments make flood risk reduction and planning decisions under climate change uncertainties. This was investigated using a serious game tool employed through eleven gaming workshops in the central Philippines to identify a set of adaptation decision archetypes. Three decision-making archetypes were established based on the combinations of determinants that included group composition, the extent and mode of collaboration, collective efficacy, location targeting preferences, and adaptation choices. We identified three adaptation governance archetypes which were: (1) *Hierarchical Alliances*, (2) *Passive Enthusiasts* and (3) *Deliberative Strategists*. We then identified how these governance archetypes responded to situational, temporal, choice, and outcome uncertainties. This uncovered six strategies used to act, reduce, supress, and forestall uncertainties: (a) resource sharing; (b) coordination; (c) early action; (d) mobilising values; (e) transferring accountability; and (f) risk balancing. Our findings contribute a new classification for adaptation governance grounded in novel methods which simulate climate futures.

Archetypes can be recognised in broader contexts by identifying contextual and normative conditions which influence the behaviours typical of a phenomenon, and thus, knowledge can be transferred between cases. By understanding these behavioural patterns, lessons across multiple scenarios can be integrated into future activities, in particular the effectiveness of responses to uncertainty and the building blocks to successful flood risk reduction. This is crucial to strengthening disaster governance for increased flood risk reduction, implementation of effective adaptation measures, and the goal of facilitating ideal decision environments for local governments.

Our findings have important implications for how we structure climate change adaptation governance. Firstly, our framework can be used to identify how to establish arrangements when specific types of uncertainties may be present in decisions. For example, where there is particularly high outcome uncertainty, our findings show the value in investing in deliberative processes. However, where choice uncertainty may be high, we show that even where there is relatively low existing efficacy to act on climate change, drawing on group values can be a powerful strategy to move toward proactive climate change adaptation.

CRediT authorship contribution statement

Zoe Latham: Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation. **Grace Barrett-Lennard:** Writing – original draft, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation. **Aaron Opdyke:** Writing – review & editing, Visualization, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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