

# Teaching Wildfire Preparedness with the Serious Game *WildWildfire!*

**Module: Natural Hazards and Risks**

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## **1. Introduction**

Wildfire evacuation preparedness has become an increasingly urgent societal challenge in the context of climate change. While wildfires have long threatened communities in fire-prone regions, recent decades have brought a marked increase in fire weather conditions, frequency, and severity, driven by rising temperatures, prolonged droughts, and land-use changes (IPCC, 2021; Seneviratne et al., 2021). These shifting dynamics introduce new layers of uncertainty for communities, particularly regarding how and when to evacuate safely.

Preparedness is widely recognised as a decisive factor in mitigating wildfire impacts, yet national survey data reveal persistent preparedness gaps. In the 2023 FEMA National Household Survey, 57% of respondents reported taking three or more preparedness actions and 51% felt personally prepared for a disaster. Awareness was a critical predictor: those who had received preparedness information were five times more likely to take multiple actions than those who had not (FEMA, 2023). However, fewer than half expressed confidence in their ability to prepare (self-efficacy) or in the effectiveness of preparation (outcome efficacy). Moreover, socioeconomic barriers limited uptake of higher-cost actions, and preparedness behaviours were uneven: assembling or updating supplies increased in 2023, while enrollment in alerts and warnings declined (FEMA, 2023).

These preparedness gaps are not evenly distributed across society. Older adults, for example, report similar perceptions of preparedness as younger groups but engage in fewer concrete actions (FEMA, 2023). Vulnerability studies show that older populations, households with limited mobility, and pet owners face barriers to evacuation, sometimes delaying or avoiding it altogether (Runefors et al., 2021; Taylor et al., 2015; ASPCA, 2021). Risk perception is also uneven: despite living in high-risk areas, only about half of residents perceive wildfires as a likely threat, compared with far higher recognition of hurricane risks (FEMA, 2023). These disparities highlight the need to address both behavioural and equity dimensions of preparedness.

Traditional information campaigns, while necessary, are insufficient to overcome these challenges. Educational strategies must do more than provide lists of actions; they need to increase confidence, improve knowledge of wildfire risks, and highlight the consequences of preparedness decisions under real-world constraints of time, uncertainty, and limited resources. Serious games offer a promising tool in this regard. By placing participants in interactive, scenario-based environments,

games allow players to experiment with strategies, confront trade-offs, and experience the consequences of action or inaction in a safe, engaging context (Solińska-Nowak et al., 2018).

This report presents *WildWildfire!*, a serious game developed within the Natural Hazards and Risks module to simulate wildfire preparation and evacuation. The game's central aim is to familiarise players with preparedness actions, decision-making under uncertainty, and the social inequalities that shape evacuation outcomes.

## 1.1 Hazard overview

Wildfires are among the most destructive natural hazards, causing widespread ecological, economic, and social disruption. In Europe, the 2023 wildfire season was among the worst this century, with over 500,000 hectares of land burned and the Evros fire in Greece surpassing 90,000 hectares, making it the largest single recorded fire in the European Union (ECHO, 2024, San-Miguel-Ayanz et al., 2023). Globally, recent seasons in Canada, Australia, and the United States have similarly illustrated the far-reaching consequences of fire events, including the destruction of homes and infrastructure, mass evacuations, and long-term health impacts linked to smoke exposure (US EPA, 2022; Harvey, 2024)

Evacuation is the most common protective action during wildfire events, yet it remains fraught with challenges. The vast majority of evacuees depend on private vehicles, as demonstrated during the 2018 Camp Fire in California, where 84% of respondents reported using exclusively a personal vehicle, while the remainder relied on a combination of modes such as walking or joining other vehicles, including those of strangers and emergency responders (Grajdura & Rowangould, 2025). This reliance on cars often creates bottlenecks, traffic delays, and significant inequities for individuals without access to reliable transport. Vulnerable groups including older adults and households with pets are particularly at risk, as they are less likely to evacuate independently and may even decide to remain behind due to mobility limitations or attachment to animals (Taylor et al., 2015; ASPCA, 2021).

These dynamics illustrate why wildfire preparedness cannot be treated as an individual issue alone but must be approached as a community challenge. Education that integrates hazard awareness with social vulnerability perspectives is essential to building resilience.

## **1.2 Report overview**

This report introduces *WildWildfire!*, a serious game designed to explore wildfire preparedness and evacuation under conditions of uncertainty and social inequality. Section 2 provides the scientific foundation, situating the game within disaster risk management (DRM), climate change adaptation (CCA), and serious games research. Section 3 presents the game itself, outlining its objectives, mechanics, and educational purpose. Section 4 reflects on the development process, highlighting collaboration, trade-offs, and lessons learned and then concludes by assessing the game's contributions to DRM education and suggesting directions for future refinement and implementation.

## **2. Literature Review & Conceptual Framing**

### **Introduction**

This section grounds *WildWildfire!* in DRM and CCA theory, clarifying its focus on strengthening preparedness behaviours under uncertainty. It also justifies the game's design choices and examines evidence on serious games as tools for disaster education.

#### **2.1 Disaster Risk Management / Climate Change Adaptation Frameworks**

Central to this is the disaster risk management cycle, which delineates four interconnected phases: mitigation, preparedness, response, and recovery (Chartoff, 2023). Mitigation encompasses actions that reduce hazard exposure or vulnerability; preparedness involves planning, training, and resource allocation; response refers to immediate actions during a disaster; and recovery targets restoration and resilience building after the event. The Sendai Framework further embeds these dimensions within global policy, emphasizing enhanced preparedness and 'building back better' in its recovery strategies (UNDRR, 2015).

In the context of wildfires, mitigation could include defensible space and structural home hardening, while preparedness involves assembling go-kits, evacuation planning, and awareness of routes. Response, marked by evacuation decisions under time pressure and uncertainty, is the core simulated experience of the game. Finally, recovery while not directly modelled underpins longer-term resilience education embedded in reflection and educational debriefs.

#### **2.2 Relevance & Specific Focus**

The game's specific pedagogical goal is to enhance the capacity of youths and adults to prepare for wildfires and to make informed evacuation choices under time constraints, particularly through private vehicle use. This focus is sharply defined rather than generic, targeting two closely linked components: (1) selection and assembly of go-kits and defensible space measures, and (2) real-time decision-making during evacuation.

## **2.3 Theoretical foundations**

The development of the game draws from several interrelated theoretical perspectives, including Protection Motivation Theory (PMT), the Protective Action Decision Model (PADM), Social Vulnerability, Community Resilience, Self-Determination Theory (SDT), Flow, and Experiential Learning. In addition, complementary perspectives such as the Theory of Planned Behaviour and the Social Amplification of Risk Framework help explain decision-making under uncertainty and social communication dynamics.

### **Protection Motivation Theory (PMT)**

PMT posits that individuals' protective actions are shaped by two types of appraisal: threat appraisal, which includes perceptions of hazard severity and vulnerability, and coping appraisal, which encompasses beliefs about response efficacy, self-efficacy, and the costs of action (Bubeck et al., 2013; Liu et al., 2024). Research consistently shows that coping appraisals, particularly self-efficacy and outcome efficacy, are stronger predictors of protective behaviour than knowledge alone (van Valkengoed and Steg, 2019; Babcicky and Seebauer, 2019). In *WildWildfire!*, these processes are simulated through the mechanics of Action and Resource cards. Action cards embody hazard encounters, thereby triggering threat appraisals, while Resource cards such as go-kit items and defensible space actions function as coping resources. When players spend resources to block penalties, they engage in a cost–benefit calculation that mirrors coping appraisal in PMT, while scoring bonuses linked to effective preparations reinforce perceptions of outcome efficacy.

### **The Protective Action Decision Model (PADM)**

PADM extends these insights by examining how people move from exposure to warnings and environmental cues to protective actions, emphasising the influence of pre-decisional processes, information sources, and time constraints (Lindell and Perry, 2012). According to PADM, protective action decisions are iterative and shaped by evolving cues from the environment and social interactions. This is reflected in the design of *WildWildfire!*, where the Preparation Phase represents the pre-decisional stage and the Disaster Phase captures time-pressured execution. The hazard die roll serves as an environmental cue that can accelerate evacuation onset, while trading and token-sharing mimic social cues that influence protective action decisions. The iterative nature

of PADM is reinforced as players revise strategies based on uncertain outcomes, such as the risks of shortcut spaces or the value of resource exchanges.

## **Social Vulnerability**

Social vulnerability theory provides another key foundation. Research demonstrates that demographic and socioeconomic factors such as age, mobility, and household composition strongly affect the ability to prepare for and respond to disasters (Cutter et al., 2003; Cutter, 2024). Vulnerability is unevenly distributed, and households with elderly members or pets often face additional barriers during evacuation (Taylor et al., 2015; ASPCA, 2021). *WildWildfire!* incorporates these insights through Character roles, including Elderly, Parent, Pet Owner, Student, and Community Leader, each associated with differential resource multipliers and priorities. These roles ensure that players experience how the same hazard context can generate unequal burdens, fostering empathy and perspective-taking while encouraging adaptation to diverse needs.

## **Community Resilience**

At the community scale, resilience theory highlights the role of social capital, collective resources, and cooperation in effective disaster response (Norris et al., 2008). Empirical studies show that participatory simulations and role-playing exercises can strengthen collective problem-solving and adaptive capacity (Fleming et al., 2020). To reflect this, *WildWildfire!* integrates Neighborly tokens and a resource-trading system that reward cooperation and resource sharing. These elements underscore the contribution of mutual aid and trust-building to successful evacuation and resilience, aligning gameplay with resilience-building strategies identified in disaster research.

Beyond behavioural and social theories, the game also draws on frameworks of learning and motivation. SDT suggests that autonomy, competence, and relatedness are key drivers of intrinsic motivation (Ryan and Deci, 2000). Experiential Learning Theory (Kolb, 1984) conceptualises learning as a cycle of concrete experience, reflective observation, abstract conceptualisation, and active experimentation. Together, these perspectives explain why serious games are powerful pedagogical tools: they can generate immersive learning experiences that go beyond knowledge transmission to change attitudes and behaviours. The design of *WildWildfire!* incorporates these principles by offering autonomy in strategic choices, competence-building through transparent

scoring, and relatedness via cooperation. Randomised hazard events provide uncertainty that sustains flow, while the structured debrief completes Kolb's experiential cycle by linking gameplay to real-world preparedness concepts.

Finally, complementary theories further enrich the conceptual foundations. The Theory of Planned Behavior (Ajzen, 1991) highlights the roles of attitudes, subjective norms, and perceived behavioural control in shaping intentions. In the game, observable cooperative behaviour and character-based empathy are designed to model subjective norms and intentions. Meanwhile, the Social Amplification of Risk Framework (Kasperson et al., 1988; Kasperson et al., 2022) helps explain how hazard perceptions are amplified or attenuated by communication and social cues. This is reflected in Action card scenarios that mimic conflicting information, delays, or misinformation, providing opportunities for players to critically assess the role of communication in evacuation decisions.

#### **2.4 Serious games evidence (effectiveness & types)**

A systematic review of 45 disaster-related games found that serious games are particularly successful at promoting hazard awareness, empathy, and perspective-taking, although rigorous evaluation of behavioural outcomes remains limited (Solińska-Nowak et al., 2018). Similarly, research on gamification in disaster education demonstrates that interactive learning environments significantly improve preparedness knowledge compared with traditional instruction (Bai et al., 2024).

One of the key strengths of serious games lies in their ability to simulate uncertainty, risk trade-offs, and social interaction in a safe environment (Hamari et al., 2016). By combining tabletop mechanics, which allow tangible interaction and group discussion, with a digital simulation, which enables rapid prototyping and large-scale testing of strategies, *WildWildfire!* adopts a hybrid approach. This dual format maximises accessibility while allowing both experiential, face-to-face play and analytical evaluation through digital replication. The integration of both modes not only fosters inclusivity but also enhances replayability and provides opportunities for more systematic learning assessments.

## **2.5 Derived learning objectives (from theory)**

Drawing on the theoretical foundations outlined above, *WildWildfire!* pursues six central learning objectives. First, it develops knowledge of key preparedness measures such as go-kits and defensible space. Second, it calibrates risk perception by exposing players to uncertain hazard onset and variable consequences. Third, it enhances self-efficacy by demonstrating that preparation enables successful coping, and fourth, it strengthens outcome efficacy by linking actions to measurable in-game benefits. Fifth, it promotes perspective-taking through differentiated character roles that highlight social vulnerability. Finally, it cultivates cooperative intent by rewarding mutual aid and negotiation, reinforcing the role of social capital in resilience.

### **3. Presentation of the Game**

#### **3.1 Objectives and Target Group**

The primary purpose of *WildWildfire!* is to function as a serious game that both educates and engages players, with learning outcomes aligned to DRM and CCA principles. Its serious goals include enhancing knowledge of wildfire preparedness, improving behavioural intentions for evacuation, strengthening self-efficacy and outcome efficacy, fostering empathy through perspective-taking, and encouraging cooperation as a resilience-building behaviour.

In terms of knowledge outcomes, the game introduces players to evidence-based wildfire preparedness measures, including go-kit assembly and defensible space creation, which are widely emphasised by organisations such as the Red Cross (2021) and CAL FIRE (2023). By requiring players to collect preparedness resources and decide whether to invest in defensible space, the game simulates the importance of pre-disaster actions. This aligns with DRM frameworks that identify preparedness as a decisive factor in reducing loss (UNDRR, 2015).

Beyond knowledge, the game targets behavioural and psychological outcomes. According to Protection Motivation Theory, protective behaviour is strongly influenced by self-efficacy and response efficacy (Bubeck et al., 2013; van Valkengoed & Steg, 2019). *WildWildfire!* operationalises these constructs by linking the ability to block hazards to prior preparedness decisions, thereby reinforcing the belief that preparation increases the likelihood of successful evacuation. Similarly, outcome efficacy is reinforced through scoring systems that reward complete go-kits and cooperative strategies.

The game also seeks to enhance empathy and equity awareness by embedding roles that reflect social vulnerability, such as Elderly or Pet Owner. Literature confirms that role-play and perspective-taking enhance recognition of equity issues in disasters (Taylor et al., 2015). By assigning asymmetric advantages, the game demonstrates how vulnerability shapes outcomes, aligning with broader CCA goals of addressing inequality (Cutter, 2024).

Cooperation is another central objective. Resilience theory underscores the importance of social capital and mutual aid in disaster contexts (Norris et al., 2008). Through Neighborly tokens and

trading mechanics, *WildWildfire!* rewards collaborative behaviour, thereby modelling resilience-enhancing practices.

The target group is intentionally broad. The game is accessible to families and schools, with a recommended age of 8+. This dual audience design builds on findings that children and youth often act as conduits of preparedness information to their families, thereby amplifying educational impact (Sturtevant & Myer, 2013).

Finally, the design carefully balances learning and fun. Elements of time pressure (hazard die), uncertainty (dice rolls, Action cards), costs (resource spending), and social interaction (trading) ensure engagement while delivering serious content. Randomness and competition sustain excitement, while cooperative play nurtures social learning. This reflects findings that engagement and enjoyment are prerequisites for effective educational games (Hamari et al., 2016; Solińska-Nowak et al., 2018).

### **3.2 Inspirations and Related Games**

The design of *WildWildfire!* was inspired by several existing board and educational games, but it also introduces innovations that address equity, cooperation, and the DRM cycle in distinctive ways.

One of the clearest influences is The Game of Life, a classic board game structured around a winding path with discrete spaces and point-based scoring. In The Game of Life, players accumulate money and achievements, with the winner determined by total wealth at the end (Hasbro, 2013). *WildWildfire!* adopts this path-based layout and cumulative scoring logic, yet adapts them to a DRM context: preparedness resources and cooperative behaviours are rewarded instead of wealth accumulation. This shift from financial success to resilience indicators reflects the educational purpose of the game.

Cooperative card and resource-collection games also informed the design. Many modern tabletop games involve assembling resource sets to achieve multipliers or bonuses, and some include trading mechanics to encourage negotiation and cooperation. *WildWildfire!* incorporates these features through the creation of go-kits, prepper kits, and trading rounds, linking them directly to

real-world preparedness concepts. This structure emphasises that resilience is strengthened not only by individual preparedness but also through collaboration.

The design also considered existing educational disaster games, notably *Stop Disasters!* developed by the UN/ISDR. This digital simulation allows players to build disaster-resilient communities by investing in structural and non-structural measures. While effective for demonstrating mitigation, it lacks emphasis on evacuation dynamics and social vulnerability (UN/ISDR, 2007). *WildWildfire!* complements this by foregrounding evacuation under uncertainty and explicitly incorporating equity issues through differentiated character roles.

From these inspirations, the team learned three key lessons. First, simplicity is critical: rules must be easy to learn while still embedding serious content. Second, a balance between realism and engagement is necessary; excessive complexity risks alienating players, while oversimplification undermines learning. Third, integrating equity and cooperation into core mechanics distinguishes *WildWildfire!* from its predecessors, aligning it more closely with DRM theory and educational practice.

### **3.3 Narrative and Setting**

The narrative of *WildWildfire!* is deliberately structured around a familiar yet urgent scenario: a wildfire is rapidly approaching a town, and residents must both prepare their households and evacuate to safety. This storyline provides a coherent “red thread” that links the two phases of the game. In the Preparation Phase, players act within their community to collect emergency supplies or invest in defensible space around their homes. In the Disaster Phase, players transition to an evacuation route where they must use those preparations to overcome hazards and reach the Safe Zone. The direct causal link between early decisions and later outcomes is central to the game’s educational purpose, emphasising how preparedness actions materially shape evacuation success.

The setting is intentionally concrete and recognisable. The board depicts a small town with key locations, including the Home, Grocery Store, Pharmacy, Gas Station, Electronics Store, and Yard. Each location corresponds to specific resources such as water, food, medicine, or fuel that players may choose to collect. The Yard represents the option of creating defensible space, reflecting the importance of mitigation alongside preparedness. Once the fire arrives, all players enter the

Evacuation Highway, a winding route marked by normal spaces, shortcut opportunities, and hazard zones, culminating in the Safe Zone. This road-based setting mirrors the reality that most wildfire evacuations are vehicle-dependent (Grajdura & Rowangould, 2025).

To follow the narrative, players must understand the purpose of resources (e.g., water or first aid to block penalties), the value of cooperation (sharing or trading to gain advantages), and the risks of chance events (uncertain die rolls or hazard cards). The competencies required to play are minimal basic reading, simple arithmetic, and strategic reasoning making the game accessible to players aged eight and above. Through its storyline and setting, *WildWildfire!* communicates the urgency of preparedness while providing an engaging and educational experience.

### **3.4 Structure and Control Mechanisms**

The structure of *WildWildfire!* combines both play-based and goal-based elements, creating a hybrid design that maximises engagement while maintaining educational integrity. It is play-based in that participants experience a dynamic, uncertain scenario where choices and dice rolls drive emergent outcomes. Yet it is also goal-based, as players are guided towards specific preparedness and evacuation objectives, and their performance is ultimately evaluated through a structured scoring system. This dual approach reflects the pedagogical intention to make learning enjoyable while also ensuring that players acquire clear lessons about preparedness and cooperation.

#### **Player guidance and information flow**

Players are guided through the game at three stages: before, during, and after play. At the beginning, rules are introduced verbally and in a written reference sheet that outlines objectives, phases, and actions. This ensures that players understand the basic mechanics and learning goals before the game begins. During play, cards and board prompts provide continual reinforcement. Resource cards indicate both their point value and their function in blocking specific hazards, while Action cards describe penalties and possible counters. Symbols on the board remind players of special spaces, such as shortcuts and hazard zones. After the game concludes, a scoring phase determines the winner, followed by a facilitated debrief. This post-game discussion draws explicit connections between in-game decisions and real-world wildfire preparedness, ensuring that the experiential learning cycle is completed.

## **Challenges incorporated into gameplay**

Several challenges are embedded to simulate the complexity of real-world evacuation. First, hazard unpredictability is modelled through dice rolls and random Action card draws, which mirror the uncertainty of wildfire spread and its cascading impacts. Second, resource scarcity is present in the limited number of Resource cards per location, requiring players to prioritise and negotiate. Third, time limits are introduced through the hazard die: rolling a six can abruptly end the Preparation Phase, forcing an early evacuation. Finally, cooperation dilemmas are woven throughout the design. Players must decide whether to share or withhold resources, balancing individual gain against potential collective benefit. These challenges are intended not only to enhance engagement but also to expose players to the trade-offs that households and communities face in wildfire contexts.

## **Embedded micro-games**

Within this overarching structure, several micro-games enrich the learning experience. The shortcut gamble introduces a probabilistic decision: a high die roll can advance a player several spaces, while failure results in skipping a turn. This risk-reward trade-off teaches players to weigh uncertainty against potential benefits. The trading phase functions as a negotiation sub-game, allowing one-for-one exchanges of Resource cards after each evacuation round. This mechanic reinforces the value of cooperation and mirrors the real-world practice of resource sharing. The third micro-game is blocking hazards with resources, which resembles a matching exercise. To avoid penalties, players must possess the correct Resource card, linking preparation in the first phase directly to outcomes in the second.

## **Scenarios incorporated**

These micro-games collectively support broader scenarios designed around key learning outcomes. “Avoid” scenarios require players to use resources to block hazards, reinforcing the protective function of preparedness. “Match” scenarios involve assembling complete go-kits or prepper kits for bonus points, modelling the advantages of comprehensive preparation. “Manage” scenarios arise as players balance the acquisition of Neighborly tokens against resource cards, reflecting the dual importance of mitigation and preparedness. Finally, “Move” scenarios centre

on progressing along the evacuation route, capturing the urgency and pace of real evacuation. Together, these scenarios integrate cognitive, behavioural, and social dimensions of DRM into accessible gameplay.

### **Duration and ending**

The game is designed to last approximately 30–45 minutes, depending on the number of players and the frequency of hazard encounters. A strict real-time clock is not imposed; rather, time pressure is simulated through the stochastic hazard die, which can trigger evacuation earlier than expected. This mechanic ensures that the sense of urgency is experienced without requiring players to race against a literal timer, thus keeping the game accessible to different age groups.

The game ends when the first player reaches the Safe Zone. All players will then count up their points to find out who the winner is.

### **3.5 Scoring and Balance Philosophy**

The scoring system in *WildWildfire!* has been carefully designed to reflect principles of DRM while ensuring fairness and sustained engagement. Victory is determined not simply by being the first to reach the Safe Zone, but by the total number of points accumulated across multiple categories. This reflects the pedagogical emphasis that preparedness and cooperation can be as decisive as speed in determining outcomes during real evacuations.

Players earn base points from Resource cards, which carry values between one and three, thereby rewarding systematic collection of essential items. Character-specific bonuses add an equity dimension: for example, the Elderly character receives additional points for medical supplies, while the Pet Owner is rewarded for food and blankets. This mechanic illustrates the differentiated needs of vulnerable groups and embeds empathy into the scoring framework (Taylor et al., 2015). Combo bonuses such as the Go-Kit (+5 points for assembling five essentials) or the Prepper Kit (+10 points for completing seven items) incentivise comprehensive preparation rather than opportunistic collecting.

Neighborly tokens provide both immediate strategic benefits during play and end-game points, with extra value for the Community Leader. This reinforces the principle that cooperation and

social capital contribute significantly to resilience (Norris et al., 2008). A Safe Zone bonus of +5 points rewards the first to arrive, but this alone is insufficient for victory, as overall scoring integrates multiple preparedness and cooperation dimensions.

### **3.6 Digital Version and AI Simulations**

Alongside the tabletop version, *WildWildfire!* has been developed as a digital, text-based simulation that runs entirely in the terminal (see <https://tinyurl.com/yeuar6uk> for a demo). The open source python code to run the demo and to analyze strategies and profiles is also available on github (<https://github.com/morganrivers/DisasterGame>) (Rivers, 2025). The digital adaptation replicates the full ruleset, allowing individual users to engage with the game outside a physical classroom or community setting. Importantly, the digital format has been used to conduct tens of thousands of rounds of play. Simplistic strategies were adopted to simulate the players and randomness was also incorporated. Character profiles were assessed for balance and fairness. These simulated playthroughs also tested the effectiveness of different strategies, such as prioritising resource collection versus focusing on defensible space.

Results from these simulations revealed that balanced strategies consistently performed best, validating the educational message that preparedness and cooperation are more effective than overreliance on speed or luck. The data also informed fine-tuning of point values, hazard probabilities, and token rewards to ensure that all character roles and strategies remained viable. This dual use as a playable digital tool and as a platform for balance testing underscores the hybrid, research-informed design philosophy of the game.

## **4. Reflection on Group Work and Development Process**

### **4.1 Introduction**

The development of *WildWildfire!* was as much about the process of collaboration as it was about the final product. While earlier sections outlined the theoretical justification and mechanics of the game, this section reflects on the lived experience of working together to bring the project to life. It examines how the group organised its workflow, the sequence of development stages, and the trade-offs we negotiated along the way. It also highlights the diverse expertise within the team, showing how disciplinary backgrounds shaped the project. Finally, it reflects on the lessons learned and considers potential future directions.

Designing a serious game is not a straightforward process. Scholars of design-based research emphasise that educational innovation evolves through iterative cycles in which theory informs practice, and practice feeds back into theory (Collins et al., 2004; Peterson, 2005). For us, this meant grappling with the challenge of simplifying complex DRM and CCA frameworks without trivialising them. In the end, our project demonstrated that game design is not simply a matter of producing rules and boards, but a dynamic form of scientific communication where collaboration, iteration, and creativity are indispensable.

### **4.2 Game Development and Project Management**

#### **Coordination and Organisation**

At the outset, we recognised that coordination was critical. The group established a rhythm of weekly meetings to discuss progress, supplemented by asynchronous collaboration using shared online Google documents and a GitHub repository. This repository became a central space for storing draft rules, Python code for the digital version, and presentation slides. Clear communication channels like Discord allowed us to respond efficiently to emerging issues, whether conceptual (such as how to represent equity in scoring) or technical (such as balancing hazard probabilities). This workflow mirrors findings in the team science literature, which

highlights the importance of shared artefacts and transparent communication for interdisciplinary collaboration (National Research Council, 2015).

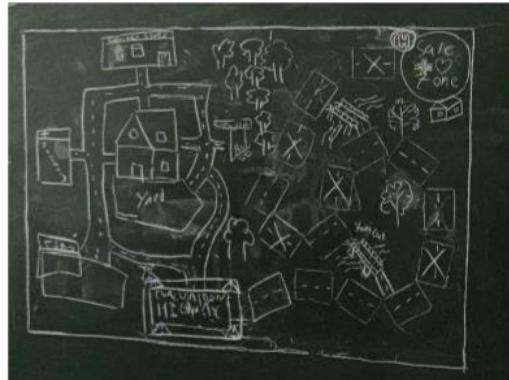
## Development Stages

Our process unfolded in a sequence that was somewhat unconventional for a board game project. We began with code before moving to physical design, and this shaped how the game evolved.

The first stage was the digital prototype, developed in Python (Rivers, 2025). Instead of sketching a board immediately, we created a rough script to simulate dice rolls, hazard probabilities, and scoring rules. Although visually minimal, this prototype allowed us to run test simulations to see how different strategies performed. For example, we could observe whether “rushing” to the safe zone consistently outperformed “stockpiling resources,” or whether cooperative behaviours offered measurable benefits. Simulation-based prototyping provided early insights into balance and fairness and reduced the risks of overcomplicating the later board design. Scholars note that computational prototypes are increasingly valuable in educational design because they allow rapid, low-cost testing of assumptions (Squire, 2011; Desrosier, 2011).

The second stage was chalkboard sketching (see Figure 1a). Once the digital prototype highlighted promising mechanics, we translated them into a rough analogue format, drawing a path and resource stations on a chalkboard. This phase gave us flexibility to visualise spatial elements such as the length of the evacuation highway and the placement of hazard and shortcut spaces. Chalkboard testing also facilitated group play in a low-cost, low-commitment format. We could erase and redraw within minutes, iterating through alternative structures until we arrived at a model that felt both playable and educational. This resonates with Salen and Zimmerman’s (2004) argument that low-fidelity prototypes are essential in exposing unforeseen design flaws.

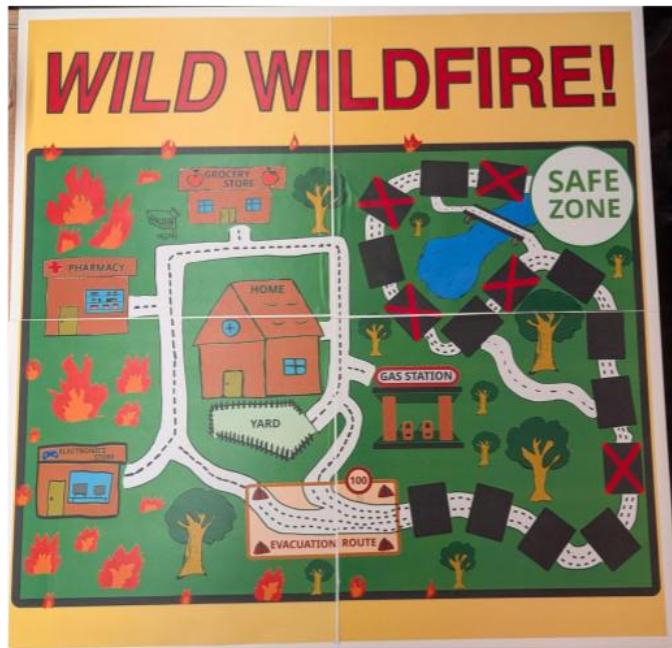
The third stage was the drawing of the physical demo board (see Figure 1b). After testing concepts digitally and visually, we invested in materials such as poster board, printed cards, dice, and tokens. The board and decks were refined into a coherent system, with improved iconography and simplified language on Action cards to ensure clarity.



(a)



(b)



(c)

**Figure 1** (a) Chalkboard sketch of the game (b) Watercolor pencil sketch (c) Final foldable board as part of portable the game box that was brought to the CLEWS excursion.

The final stage was the digitalization of the board with the Inkscape open source vector graphics software, printing, and inserting into a durable, portable cardboard game box with convenient storage for game pieces (see Figure 2). The transition from chalkboard to finished materials represented the consolidation of our earlier iterative work, combining the precision of computational testing with the embodied, social feedback of face-to-face play.



**Figure 2** (a) An early physical pilot game (b) Unpacking the game for a round of play at the CLEWS excursion (c) The beginning of the disaster phase for of the trial game

### Trade-offs in Design

At every stage, we negotiated trade-offs between competing priorities. One constant tension was between realism and playability. While it was tempting to incorporate detailed hazard scenarios, we realised this would overwhelm players, especially younger ones. We chose to model hazards at a level that was realistic enough to spark reflection but simple enough to sustain engagement. Serious games literature repeatedly stresses that striking this balance is crucial: too much realism can reduce playability, while excessive simplification risks undermining educational value (Connolly et al., 2012).

Another trade-off involved competition and cooperation. Competition provides excitement and motivates players, but resilience in real disasters depends heavily on cooperation and mutual aid (Norris et al., 2008). Our solution was hybrid: players compete to win, but they also gain points and strategic advantages from cooperative behaviours such as trading resources or using Neighborly tokens. This reflects findings in cooperative learning research, which show that structured interdependence fosters both engagement and prosocial behaviour (Johnson & Johnson, 2009; Gillies, 2016).

Finally, we confronted the trade-off between complexity and accessibility. Our early iterations of Action cards contained too much detail, leading to confusion. Simplification was necessary to ensure that the game was accessible to younger audiences while still embedding key DRM lessons. Wouters and van Oostendorp (2013) argue that instructional support and clear scaffolding improve outcomes in game-based learning, and our revisions reflected this principle.

### **Division of Labour and Expertise**

The division of labour combined role specialisation with shared responsibilities. Coding and AI simulations were handled by members with programming backgrounds, while literature synthesis and rule drafting were taken up by those with stronger academic writing skills. Visual design, including the layout of the board and cards, drew on members with graphic expertise. However, activities such as chalkboard playtesting and refining mechanics were shared deliberately. This hybrid approach fostered both efficiency and collective ownership.

Our interdisciplinary backgrounds proved invaluable. Students from geography and environmental management contributed hazard knowledge, while those with education and communication expertise emphasised accessibility and engagement. Technical skills enabled the digital version and simulations, while creative writing helped craft narrative and card texts. Research on interdisciplinary collaboration confirms that successful projects depend on both differentiated expertise and joint sense-making (National Research Council, 2015).

## **4.3 Lessons Learned**

### **Simplifying Theory Without Trivialising It**

One of the hardest challenges was simplifying theoretical frameworks without stripping them of meaning. Protection Motivation Theory and the Protective Action Decision Model are dense and multi-layered, but reducing them to mechanics such as Action and Resource cards helped make them tangible. Spending a Resource card became a metaphor for “coping costs,” while blocking hazards reinforced “response efficacy.” These metaphorical translations align with Squire’s (2011) observation that games are effective when they render abstract concepts into lived experiences.

### **Embedding Equity and Cooperation**

Another success was embedding equity and cooperation into the core of the game rather than as secondary features. Character roles, such as Elderly or Pet Owner, were designed to reflect social vulnerability, giving players different needs and resource priorities. Neighborly tokens incentivised cooperation, echoing research that highlights the role of social capital in community resilience (Aldrich, 2012). During playtesting, these features regularly triggered discussions about fairness, trade-offs, and mutual support, demonstrating that players were not just accumulating points but engaging with equity and resilience. This aligns with Johnson and Johnson’s (2009) findings that structured cooperation enhances empathy and understanding.

### **Translating Science Into Playable Rules**

The iterative cycle of design and testing highlighted the importance of translating scientific literature into rules that could be played and understood. Theories provided scaffolding, but it was only through repeated testing that we confirmed whether the intended learning outcomes were being achieved. This echoes Collins’ (2004) emphasis on design-based research, in which practical trials validate both theory and design.

### **Serious Games as Scientific Communication**

Perhaps the most profound lesson was recognising serious games as a form of scientific communication. Unlike lectures or reports, games create embodied experiences where players enact preparedness strategies and live with consequences. This is consistent with Kolb’s (1984)

experiential learning cycle, where learning progresses through concrete experience, reflection, abstraction, and experimentation. For us, the debrief discussions after gameplay were as critical as the game itself, allowing players to connect in-game choices with real-world preparedness.

#### 4.4 Outlook and Future Directions

The experience of developing *WildWildfire!* highlighted not only the potential of the game itself but also avenues for extending its educational value.

One direction is the creation of a classroom toolkit, including lesson plans, discussion prompts, and structured debriefs. Research indicates that instructional support enhances the effectiveness of serious games by helping learners connect play with broader concepts (Wouters & van Oostendorp, 2013). Providing teachers with scaffolding would help ensure that the game's lessons on preparedness and cooperation are reinforced.

Another extension involves developing regional Action card decks to reflect hazards specific to different contexts, such as European wildfires or Australian bushfires. This would improve cultural and situational relevance, increasing the game's global applicability. At the same time, further work on accessibility is essential. Following human-centred design principles, we plan to refine features such as colour-blind-safe palettes, plain language rules, and large-print cards (ISO, 2019).

We also see potential in hybrid delivery, integrating the digital and physical versions. The digital simulation could provide rapid “what-if” scenarios, while the tabletop game could support face-to-face interaction and reflection. This hybrid model could be particularly valuable in classrooms, offering flexibility and opportunities for evaluation.

Finally, testing the game in a real-world setting as a pilot at the CLEWS excursion provided insight into future modifications of the game – feedback from fellow students led us to consider revealing the action cards at the start of the trade, to improve knowledge of which resources are necessary to collect in the pre-disaster phase and improve memory of what resources are useful for which future wildfire contexts. We may also consider limiting the accessibility of the items, for example

with a rule that allows only one player per house, for increased realism, and increased player-player interaction during the preparation phase.

In the future we hope to conduct further pilot testing to evaluate the game's educational impact. Using pre- and post-tests of knowledge, brief scales of self- and outcome efficacy, and behavioural-intention measures, we could systematically assess outcomes. Meta-analyses suggest that serious games deliver moderate but reliable improvements in knowledge and motivation (Connolly et al., 2012; Lamb et al., 2018). Educational pilot testing would therefore not only validate our design but also provide evidence of its contribution to DRM education.

## 5 Conclusion

Developing *WildWildfire!* demonstrated the power of combining scientific theory with creative design. Abstract frameworks from DRM and CCA became concrete through game mechanics, and iterative cycles of coding, sketching, and playtesting refined them into a playable form. The process revealed the importance of balancing realism with playability, competition with cooperation, and complexity with accessibility.

Equally important, the project underscored the value of interdisciplinary collaboration. Each team member brought unique expertise, from coding to visual design to DRM scholarship, and the project succeeded precisely because of this diversity. Ultimately, the project reinforced our belief that serious games are more than educational novelties: they are powerful, research-informed tools for communicating science, engaging learners, and strengthening community resilience.

## REFERENCES

- Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50(2), 179–211. [https://doi.org/10.1016/0749-5978\(91\)90020-T](https://doi.org/10.1016/0749-5978(91)90020-T)
- Aldrich, D. P. (2012). *Building resilience : social capital in post-disaster recovery*. The University Of Chicago Press.
- ASPCA. (2021, September 13). *New ASPCA Survey Reveals 83 Percent of Pet Owners Live in an Area Impacted by Disasters, Yet Less Than Half Have a Preparedness Plan in Place*. ASPCA. <https://www.aspca.org/about-us/press-releases/new-aspca-survey-reveals-83-percent-pet-owners-live-area-impacted-disasters>
- Babcicky, P., & Seebauer, S. (2019). Unpacking Protection Motivation Theory: evidence for a separate protective and non-protective route in private flood mitigation behavior. *Journal of Risk Research*, 22(12), 1–18. <https://doi.org/10.1080/13669877.2018.1485175>
- Bai, S., Zeng, H., Zhong, Q., Shen, Y., Cao, L., & He, M. (2024). Application of Gamification Teaching in Disaster Education: Scoping Review. *JMIR Serious Games*, 12, e64939–e64939. <https://doi.org/10.2196/64939>
- Bubeck, P., Botzen, W. J. W., Kreibich, H., & Aerts, J. C. J. H. (2013). Detailed insights into the influence of flood-coping appraisals on mitigation behaviour. *Global Environmental Change*, 23(5), 1327–1338. <https://doi.org/10.1016/j.gloenvcha.2013.05.009>
- CAL FIRE. (2025). *Home - Ready for Wildfire CAL FIRE Safety & Preparedness Tips*. Ready for Wildfire. <https://readyforwildfire.org/>
- Chartoff, S. E., & Roman, P. (2023, August 28). *Disaster planning*. PubMed; StatPearls Publishing. <https://www.ncbi.nlm.nih.gov/books/NBK470570/>

Collins, A., Joseph, D., & Bielaczyc, K. (2004). Design Research: Theoretical and Methodological Issues. *Journal of the Learning Sciences*, 13(1), 15–42.

[https://doi.org/10.1207/s15327809jls1301\\_2](https://doi.org/10.1207/s15327809jls1301_2)

Connolly, T. M., Boyle, E. A., MacArthur, E., Hainey, T., & Boyle, J. M. (2012). A systematic literature review of empirical evidence on computer games and serious games. *Computers & Education*, 59(2), 661–686. <https://doi.org/10.1016/j.compedu.2012.03.004>

Cutter, S. L. (2024). The Origin and Diffusion of the Social Vulnerability Index (SoVI). *International Journal of Disaster Risk Reduction*, 109, 104576–104576.

<https://doi.org/10.1016/j.ijdrr.2024.104576>

Cutter, S. L., Boruff, B. J., & Shirley, W. L. (2003). Social Vulnerability to Environmental Hazards. *Social Science Quarterly*, 84(2), 242–261. <https://doi.org/10.1111/1540-6237.8402002>

Desrosier, J. (2011). Rapid Prototyping Reconsidered. *The Journal of Continuing Higher Education*, 59(3), 135–145. <https://doi.org/10.1080/07377363.2011.614881>

ECHO. (2024, November 19). *2023 among the 5 worst years for wildfires in Europe, Commission report shows*. European Civil Protection and Humanitarian Aid Operations. [https://civil-protection-humanitarian-aid.ec.europa.eu/news-stories/news/2023-among-5-worst-years-wildfires-europe-commission-report-shows-2024-11-19\\_en](https://civil-protection-humanitarian-aid.ec.europa.eu/news-stories/news/2023-among-5-worst-years-wildfires-europe-commission-report-shows-2024-11-19_en)

FEMA (2023) *2023 National Household Survey on Disaster Preparedness*. Washington, D.C.: Federal Emergency Management Agency. Available at: [https://preparede.org/wp-content/uploads/2024/08/fema\\_national\\_household\\_survey\\_2023.pdf](https://preparede.org/wp-content/uploads/2024/08/fema_national_household_survey_2023.pdf) (Accessed: 27 September 2025).

Fleming, K., Abad, J., Booth, L., Schueller, L., Baills, A., Scolobig, A., Petrovic, B., Zuccaro, G., & Leone, M. F. (2020). The use of serious games in engaging stakeholders for disaster risk

reduction, management and climate change adaption information elicitation. *International Journal of Disaster Risk Reduction*, 49, 101669. <https://doi.org/10.1016/j.ijdrr.2020.101669>

Gillies, R. (2016). Cooperative learning: Review of research and practice. *Australian Journal of Teacher Education*, 41(3), 39–54. <https://doi.org/10.14221/ajte.2016v41n3.3>

Grajdura, S., & Rowangould, D. (2025). Understanding wildfire evacuees' perceived safety on their evacuation route: A study of the 2018 Camp Fire. *Transportation Research Interdisciplinary Perspectives*, 31, 101392. <https://doi.org/10.1016/j.trip.2025.101392>

Hamari, J., Shernoff, D. J., Rowe, E., Coller, B., Asbell-Clarke, J., & Edwards, T. (2016). Challenging games help students learn: An empirical study on engagement, flow and immersion in game-based learning. *Computers in Human Behavior*, 54, 170–179. <https://doi.org/10.1016/j.chb.2015.07.045>

Harvey, F. (2024, August 13). *Canada's 2023 wildfires produced nearly a decade's worth of blaze emissions*. The Guardian; The Guardian. <https://www.theguardian.com/environment/article/2024/aug/13/canada-2023-wildfires-nearly-decade-worth-blaze-emissions>

IPCC. (2021). *Climate Change 2021: The Physical Science Basis*. IPCC. <https://www.ipcc.ch/report/ar6/wg1/>

ISO. (2019). *ISO 9241-210:2019*. ISO. <https://www.iso.org/standard/77520.html>

Johnson, D. W., & Johnson, R. T. (2009). An Educational Psychology Success story: Social Interdependence Theory and Cooperative Learning. *Educational Researcher*, 38(5), 365–379. <https://doi.org/10.3102/0013189X09339057>

Kasperson, R. E., Renn, O., Slovic, P., Brown, H. S., Emel, J., Goble, R., Kasperson, J. X., & Ratick, S. (1988). The Social Amplification of Risk: A Conceptual Framework. *Risk Analysis*, 8(2), 177–187. <https://doi.org/10.1111/j.1539-6924.1988.tb01168.x>

Kasperson, R. E., Webler, T., Ram, B., & Sutton, J. (2022). The social amplification of risk framework: New perspectives. *Risk Analysis*, 42(7), 1367–1380. <https://doi.org/10.1111/risa.13926>

Kolb, D. A. (1984). *Experimental Learning: Experience as the Source of Learning and Development*. Prentice-Hall.

[https://www.researchgate.net/publication/235701029\\_Experiential\\_Learning\\_Experience\\_As\\_The\\_Source\\_Of\\_Learning\\_And\\_Development](https://www.researchgate.net/publication/235701029_Experiential_Learning_Experience_As_The_Source_Of_Learning_And_Development)

Lamb, R. L., Annetta, L., Firestone, J., & Etopio, E. (2018). A meta-analysis with examination of moderators of student cognition, affect, and learning outcomes while using serious educational games, serious games, and simulations. *Computers in Human Behavior*, 80, 158–167.

<https://doi.org/10.1016/j.chb.2017.10.040>

Lindell, M. K., & Perry, R. W. (2011). The Protective Action Decision Model: Theoretical Modifications and Additional Evidence. *Risk Analysis*, 32(4), 616–632.

<https://doi.org/10.1111/j.1539-6924.2011.01647.x>

Liu, D., Chang, X., Wu, S., Zhang, Y., Kong, N., & Zhang, X. (2024). Influencing Factors of Urban Public Flood Emergency Evacuation Decision Behavior Based on Protection Motivation Theory: An Example from Jiaozuo City, China. *Sustainability*, 16(13), 5507–5507.

<https://doi.org/10.3390/su16135507>

National Research Council. (2015). *Enhancing the Effectiveness of Team Science*. National Academies Press. <https://doi.org/10.17226/19007>

Norris, F. H., Stevens, S. P., Pfefferbaum, B., Wyche, K. F., & Pfefferbaum, R. L. (2008). Community Resilience as a Metaphor, Theory, Set of Capacities, and Strategy for Disaster Readiness. *American Journal of Community Psychology*, 41(1-2), 127–150.

<https://doi.org/10.1007/s10464-007-9156-6>

Red Cross. (2021). *Wildfire Safety*. American Red Cross; The American National Red Cross.  
<https://www.redcross.org/get-help/how-to-prepare-for-emergencies/types-of-emergencies/wildfire.html>

Rivers, M. (2025). *DisasterGame: Wildfire Evacuation Game* [Computer software]. GitHub.  
[https://github.com/morganrivers/DisasterGame \(github.com\)](https://github.com/morganrivers/DisasterGame)

Runefors, M., Jonsson, A., & Bonander, C. (2021). Factors contributing to survival and evacuation in residential fires involving older adults in Sweden. *Fire Safety Journal*, 103354.  
<https://doi.org/10.1016/j.firesaf.2021.103354>

Ryan, R. M., & Deci, E. L. (2000). Self-determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-being. *American Psychologist*, 55(1), 68–78.  
<https://doi.org/10.1037/0003-066X.55.1.68>

Salen, K., & Zimmerman, E. (2004). *Rules of Play: Game Design Fundamentals*. Mit Press.  
San-Miguel-Ayanz, J., Durrant, T., Boca, R., Maianti, P., Liberta, G., Oom, F., Branco, A., De, R. D., Suarez-Moreno, M., Ferrari, D., Roglia, E., Scionti, N., Broglia, M., Onida, M., Tistan, A., & Loffler, P. (2023). Forest Fires in Europe, Middle East and North Africa 2023. *JRC Publications Repository*. <https://doi.org/10.2760/8027062>

Seneviratne, S. I., Zhang, X., Adnan, M., Badi, W., Dereczynski, C., Di Luca, A., Ghosh, S., Iskander, I., Kossin, J., Lewis, S., Otto, F., Pinto, I., Satoh, M., Vicente-Serrano, S. M., Wehner, M., Zhou, B., & Greve, P. (2021). *Weather and Climate Extreme Events in a Changing Climate*

(*Chapter 11*) (V. Masson-Delmotte, P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, K. Yelekçi, R. Yu, & B. Zhu, Eds.). Pure.iiasa.ac.at; Cambridge University Press. <https://pure.iiasa.ac.at/id/eprint/19093/>

Solinska-Nowak, A., Magnuszewski, P., Curl, M., French, A., Keating, A., Mochizuki, J., Liu, W., Mechler, R., Kulakowska, M., & Jarzabek, L. (2018). An overview of serious games for disaster risk management – Prospects and limitations for informing actions to arrest increasing risk. *International Journal of Disaster Risk Reduction*, 31, 1013–1029.

<https://doi.org/10.1016/j.ijdrr.2018.09.001>

Squire, K. (2011). *Video games and learning : teaching and participatory culture in the digital age*. Teachers College Press.

Sturtevant, V., & Myer, G. (2013). *Fire Up: youth working with communities to adapt to wildfire*. <https://doi.org/10.2737/nrs-rn-163>

Taylor, M., Lynch, E., Burns, P., & Eustace, G. (2015). The preparedness and evacuation behaviour of pet owners in emergencies and natural disasters. *Australian Journal of Emergency Management*, 30(2), 18–23. <https://researchers.westernsydney.edu.au/en/publications/the-preparedness-and-evacuation-behaviour-of-pet-owners-in-emergence>

UN/ISDR. (2007). *Stop Disasters!* Stopdisastersgame.org. <https://www.stopdisastersgame.org/>  
UNDRR. (2015). *Sendai Framework for Disaster Risk Reduction 2015-2030*. UNDRR. <https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030>

US EPA. (2025). *Document Display (PURL) | NSCEP | US EPA*. Epa.gov. <https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P10135FE.TXT>

van Valkengoed, A. M., & Steg, L. (2019). Meta-analyses of factors motivating climate change adaptation behaviour. *Nature Climate Change*, 9(2), 158–163. <https://doi.org/10.1038/s41558-018-0371-y>

## APPENDIX (Photos and Figures)

