The Uncertainty Contagion: Revealing the Interrelated, Cascading Uncertainties of Managed Retreat

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Abstract: Managed retreat presents a dilemma for at-risk communities, and the planning practitioners and decisionmakers working to address natural hazard and climate change risks. The dilemma boils down to the countervailing imperatives of moving out of harm's way versus retaining ties to community and place. While there are growing calls for its use, managed retreat remains challenging in practice—across diverse settings. The approach has been tested with varied success in a number of countries, but significant uncertainties remain, such as regarding who 'manages' it, when and how it should occur, at whose cost, and to where? Drawing upon a case study of managed retreat in New Zealand, this research uncovers intersecting and compounding arenas of uncertainty regarding the approach, responsibilities, legality, funding, politics and logistics of managed retreat. Where uncertainty is present in one domain, it spreads into others creating a cascading series of political, personal and professional risks that impact trust in science and authority and affect people's lives and risk exposure. In revealing these mutually dependent dimensions of uncertainty, we argue there is merit in refocusing attention away from policy deficits, barrier approaches or technical assessments as a means to provide 'certainty', to instead focus on the relations between forms of knowledge and coordinating interactions between the diverse arenas: scientific, governance, financial, political and socio-cultural; otherwise uncertainty can spread like a contagion, making inaction more likely.

Keywords: managed retreat; uncertainty; managed realignment; community relocation; climate change adaptation; disaster risk reduction; planning; governance

1. Introduction

The projected impacts of climate change combined with legacy development and urbanization means that more people and assets will be exposed to natural hazard risks over the coming decades. Some of these risks can be calculated and managed effectively, particularly in the short and medium term, by technical approaches designed to protect people and assets. This strategy typically seeks to scientifically characterize and quantify risks, and translate this data into language that is useful for policy and practice, such as probability assessments, cost–benefit analyses, or confidence/likelihood thresholds. However, as the projected costs of protection or damage rise, and the difficulties in predicting long-term futures become more evident, governments and communities around the world are beginning to recognize managed retreat is an important approach to reduce risk and build resilience over the long-term [1–7].

Managed retreat can be defined as a deliberate strategy to remedy unsustainable land use patterns that expose people, ecosystems, and assets to significant natural (and socio-natural) hazard and

climate change induced risks [8]. The benefits of this strategy stretch beyond risk management to also include the restoration of land and ecosystem functions, and the removal of long-term risk management liabilities and emergency management costs. The strategy can be applied to a range of risks across varying spatio-temporal scales, and encompasses planned relocation of entire communities, strategic realignment of critical infrastructure, and more site-and asset-based, responses [1,3,8–10]. It holds potential to create more equitable and sustainable outcomes compared to ad-hoc, reactive or unmanaged relocations, such as those associated with migration and displacement, or in comparison to at-risk communities remaining in situ but subjected to an uncertain future with the prospect of escalating risk and declining investment.

While managed retreat has a compelling scientific logic, in practice it has many social, cultural, political, institutional, and economic challenges. For example, controversy often surrounds the approach due to the impacts of detachment from place, the strong desire to protect property rights and maintain the status quo, large up-front costs, logistical intricacy, and the political propensity to favor easier short-term fixes over more difficult longer-term resilience options [1,4,5,8,11–19]. Managed retreat can also be socially and culturally disruptive, and may actually increase, rather than reduce, vulnerability. Further, the complex power and social relations between land, people and risk means the governance of managed retreat is highly complex, involving multiple stakeholders with manifold interests. In short, at risk communities and their governing authorities face a dilemma. On the one hand, remaining in situ enables people to pursue their livelihoods and retain cultural, social and place-based community ties. However, then they may be predisposed to severe harm and even disaster. On the other, managed retreat can eliminate place-based exposure to harm. However, livelihoods may be disrupted, and community ties broken. To compound matters, the prospect of future harm is invariably shrouded in layers of uncertainty. While we can be certain risks will increase, it is hard to predict when, where and how fast this may be manifest. It is no surprise that in this ambiguous socio-political environment, despite significant investment in scientific data to increase confidence, attempts to implement managed retreat invoke public dispute and litigation [1,14,18,20–22].

While the managed retreat dilemma is typically positioned between the compelling scientific risk reduction imperative and substantial political unpalatability, in this paper, we seek to reframe this dilemma as involving more complex relations between multiple intersecting uncertainties, which we argue provides deeper explanatory power and new insights about its potential resolution. Although there is considerable attention within disaster and climate research on ways to address the scientific uncertainty associated with responses to extreme events and climate change, such as confidence levels on probabilities of hazards or climate futures, this technical uncertainty is intertwined with equally complex social, cultural, political, institutional, and funding uncertainties. In practice, managed retreat provokes vexing questions, such as the 'right' timing for retreat to occur; the most suitable place to relocate to; or who should pay and how much. These are not simple questions that can be solved by more knowledge concerning future climatic behaviour; they are complex questions rooted in divergent values, needs, and interests that differ spatially within and between countries and communities. Put differently, these questions go well beyond *scientific* risk and uncertainty. There is significant "governance uncertainty as to how communities and governments will implement adaptation" [18] (p. 205). As such, realizing the potential contribution of managed retreat as a resilience strategy necessitates better understanding about the intertwined uncertainties and wider political risks that become visible as managed retreat experiments unfold in diverse local settings from Alaska to Australia and New Zealand [5,16,17,21,23].

This article repositions the managed retreat dilemma and consequent inaction from being less a *scientific* or *managerial* problem—about a lack of data or policy—to be a relational challenge. This reframing highlights the uneven ways that diverse 'uncertainties' become known or can be known, their varied power, and the ways they are responded to, whether in formal institutional arrangements or through lived experiences. It also brings to the fore their compounding interplay, which indicates the need for deeper understanding about the relational nature of the governance challenge. We identify

and analyze the intersecting uncertainties surrounding the governance of managed retreat using a real-world case study, yielding insights for both practice and theory. For practice, we identify the selective ways by which diverse uncertainties become visible within both the scientific and governance arenas, and the ways these exhibit compounding and cascading effects that inhibit action—or if action ensues, explains why action is met with resistance. Significantly, these arenas are trans-disciplinary in nature, with each requiring diverse knowledge and 'joined up' praxis to reveal and address their interconnected uncertainties. For theory, in situations showing significant 'wickedness' like managed retreat, we recommend a shift away from the traditional focus on uncertainty as a *subject* of knowledge—a means by which a phenomena is quantified or reduced—towards uncertainty as an *object* of knowledge—how it becomes known and by whom—which we argue is critical to understanding the difficulties in translating and integrating multiple knowledges, including the underlying science, local and traditional knowledges, into action. Together this perspective foregrounds a relational understanding of managed retreat that reflects the interacting and compounding nature of manifold uncertainties associated with it—the uncertainty contagion—and the ways that inaction in one arena may not be resolved by action in another.

2. Materials and Methods

The methodology involved a case study of Matatā, a small rural coastal community in the Bay of Plenty (BOP) region on the North Island of New Zealand. This site was chosen as it is the location of one of the few attempts to implement a managed retreat strategy in the country and, as such, reveals the dilemma-laden nature of this strategy, and the associated uncertainties and implementation challenges. In May 2005, a torrential downpour triggered landslips, flooded the nearby Awatarariki stream and catalyzed debris flows that destroyed 27 homes and damaged a further 87 properties in the township [24]. Since that time there have been ongoing discussions, investigations and negotiations between the authorities, experts and the community concerning the preferred risk management approach. This process eventuated in a local government decision to activate managed retreat from the Awatarariki debris flow fanhead some 14 years after the initial disaster. As there was no suitable New Zealand precedent to draw upon, the town became a site at which the many dilemmas, uncertainties, and perspectives on managed retreat were brought into sharp focus.

The research initially involved a desktop analysis of the key planning provisions that established the framework for decision-making, the supplementary technical risk reports that provided much of the evidence base for action, and the media coverage related to the situation. This regulatory, institutional and media focus was complemented by 17 semi-structured interviews involving members of the community living within the high-risk zone, as well as technical experts, politicians, and council staff charged with the responsibility to reduce the risk. The interviewees were selected via a purposive sampling approach and snowball strategy [25] designed to capture the diverse perspectives from the differing key actors and agencies directly associated with the case. Three broad groups were identified: involvement in governance, policy or project roles, for example, consensus development groups, regional and district council staff and politicians; technical and scientific experts related to the calculation of risk and uncertainty; and members of the community who are property owners within the high-risk zone or mentioned in media releases from 2005 to 2017. Selected participants remain anonymous, but include environmental planners, technical experts and project managers, politicians, affected community members and an iwi (Māori tribe) representative.

The interviews afforded rich interpretive data to provide insights about decision-making processes, the political issues at play, and the human costs that accumulated as uncertainties were compounded and prolonged. While the interviews were semi-structured, given the lived experiences and feelings associated with this high-profile case there were also open-ended questions to allow for flexibility and expression of thought [26]. The structure and content of the interview questions focused on understanding the roles and experiences of participants, revealing their decision-making logics and rationales at each step of the process, how they responded to uncertainty, and the key barriers, enablers

and lessons learned. Where consent was given, interviews were digitally recorded, and notes taken. Prior to conducting the interviews, the aims of the research, its scope, and ethical considerations were discussed with participants, who all gave their informed consent. The data was inductively coded, with each document and interview transcript organized thematically according to key words, phrases and topics.

Together this research design enabled insights into the suitability of prevailing decision-making frameworks, the ways that these were interpreted and implemented, and the economic, political, cultural, and social issues at play. More explicitly with regard to this article, it also shed light on the multiple, intersecting dimensions of uncertainty; and how an uncertain governance framework created cascading social, political, institutional, and funding uncertainties. The nature of these uncertainties contributed to protracted post-disaster trauma for the communities who remained in limbo, and at risk, 14 years later.

3. The Certainty of Managed Retreat in an Uncertain World

We now draw upon uncertainty literature to reveal the difficulties decisionmakers face in enabling managed retreat. This is delineated into two specific areas: first, how uncertainty becomes known, by whom, and how; and second, how this knowledge subsequently elicits a response, e.g., within a policy setting, or prompts more scientific investigation or innovation in praxis. These considerations are important because they can advance understanding about the relationship between the production of science and its impact upon practice, which is at the very heart of the managed retreat dilemma.

The increasing involvement of social scientists in research on climate change and natural hazard risk over the last few decades has driven new understandings regarding uncertainty as a concept and as a governance challenge. The IPCC provides a valuable foundation for unpacking how scientific uncertainty has been framed, by whom, and how this is communicated within and between scientific and policy realms. In the assessment reports we see the gradual emergence of the main concerns and the preferred response strategies, for example, the growing use of multiple models, or multiple strands of evidence beyond models, the linking of observations and models, the rise of expert judgement to help narrow uncertainty ranges, the construction of future scenarios, and the use of precisely defined language to convey the assessed likelihood of an outcome. These issues similarly underpin managed retreat deliberations in the face of climate change which, as a starting point, invariably involves a scientific calculation of the level of risk that prevails in a locality, and is typically ascertained by modelling inputs and technical risk assessments [27,28]. These reports also help to highlight different *dimensions* of scientific uncertainty, such as technical, methodological, epistemic and aleatory sources of uncertainty. For instance, epistemic uncertainty is the imperfection of knowledge (also termed completeness, subjective, or systematic uncertainty), and aleatory uncertainty represents the inherent randomness of human and natural systems that cannot be reduced (also referred to as variability, stochastic, random or ontic uncertainty) [27,29–31]. Unlike aleatory uncertainty, epistemic uncertainty can be quantified and mitigated, but even then new information can reveal new uncertainties [27].

This discussion of knowledge and uncertainties about what is and can be known is useful because it brings into focus the influences of the professions and disciplines that have traditionally been involved in the risk and uncertainty fields, where modelling and engineering have played a strong role, and which are gradually becoming more influenced by the social sciences. It also highlights the long-standing science-policy logic that seeks to increase confidence concerning future risks so that decision-makers can be more confident in responding in the present [32].

Knowledge is not, however, simply a process of gradually accumulating evidence and confidence, or understanding variability. New science can uncover fresh issues and insights, while uncertainty ranges may even widen as a result of new data. For example, within the natural hazard and climate fields, science is uncovering new dynamic system feedbacks, a deeper understanding of compounding and cascading risks, and the complex interactions between and within natural and social worlds [33–36] Meanwhile, within the social sciences, increasing attention is being focused on the political nature of

science, its selective construction and representation, and the problematic ways careful caveats can be eroded in the transition from science to policy [37–40]. Moreover, there are active lobby groups producing competing knowledge claims, the rise of post-truth politics, more awareness about the role of ideology and values, and even the emergence of new theoretical concepts, like agnotology, which seek to better understand the *deliberate* production of uncertainty to inhibit confidence in public policy [41]. While there will always be a role for scientific knowledge as an authoritative way to calculate risk and assess uncertainty, the increasing technical complexity also means that scientific assessments of uncertainty can be subject to 'black-boxing', a process whereby the inner workings are difficult to understand, even by other experts, which has wider implications for social justice, and public understanding and scrutiny [37,42].

Given the inherent difficulties in revealing and managing uncertainties, increasing attention has been focused on how it is conceptualized. Rather incongruously, uncertainty is both fundamental to any scientific endeavor and is an amorphous and ambiguous term in its own right, due to its diverse applications in theory and practice. Academic scholarship aiming to reveal different typologies of uncertainty helps reveal new dimensions and arenas beyond a simple deficit of data or confidence. These nuanced perspectives blur the delineation between environmental and process uncertainty [43] for decision-making, or may also question the simplistic 'tame-wicked' binary [44] associated with difficult decisions. For instance, in a review of environmental risk assessments, Skinner and colleagues [27] (p. 213–214) identify a concern regarding how uncertainty becomes known and understood by revealing inconsistencies and contradictions in the use of terminology and dimensions of interest between similar technical assessments. They develop a taxonomy that categorizes uncertainty into two main types (epistemic and aleatory), seven location-based types (system processes, data, model, human, language, variability and decision) and a further five levels of uncertainty (determinacy, statistical, scenario, ignorance and indeterminacy). Other typologies highlight the difference between fields of uncertainty. These include, for instance, geopolitical, financial, institutional, spatial, strategic, and climate change uncertainty [27,45–50]. With particular relevance for managed retreat, Walker, et al. [51] point out that decision-making associated with the distant future is beset by uncertainties that cannot be reduced by information gathering and statistical analysis. Such situations have been characterized as having 'deep' uncertainty where agreement is difficult on which model to use, how uncertainty should be represented, or the desirability of alternative outcomes [52]. This perspective seeks to address uncertainty by linking the inevitably partial evidence base with strategies to build adaptive capacity of socio-ecological systems, enhancing flexibility to adjust to dynamic conditions [53–55].

Revealing the complexity of uncertainty underscores its many dimensions, from a basic lack of information to what can even be knowable, the variety of means by which these could or should be mitigated, and deepening understanding about the intricate interrelationships between academic disciplines and their suitability towards revealing and understanding different dimensions of uncertainty. These insights also underscore how different approaches to conceptualizing uncertainty can lead to very contrasting methods, tools, and demands for practice [31].

This theoretical reflection begins to deepen the understanding of real-world managed retreat decisions, and the vexing political and institutional questions that inhibit action, such as how managed retreat will be implemented, by whom, when, and at whose cost? To extend the uncertainty discussion, issues in this arena can result from ambiguity surrounding responsibility, laws, direction, coordination and capacity to act. Therefore, in addition to scientific uncertainty, composite problems such as managed retreat, which cross multiple disciplines and face many implementation challenges [8] are constrained by institutional uncertainty [1,5,17,23,56]. As recognized by Koppenjan and Klijn [50], this can result in a high degree of doubt about how the process could or should unfold, the interactions between actors, and who is responsible for action. Institutional uncertainty can be difficult to overcome due to how existing frameworks are "anchored in formal legal frames, deeply-rooted informal institutions or long-term societal transition processes" [50] (p. 7). A further dimension of concern is the question of 'managed retreat to where?', which challenges implementation prospects, effectiveness

and sustainability, causing extended 'waiting' and temporal uncertainty about the future for affected people and communities.

This section is designed to emphasize that while there has been a tendency to consider uncertainty in the context of specific issues, or thematically as a scientific problem to be mitigated, uncertainties are complex, multifaceted and interdependent. This is, in part, due to the nature of decision-making where, for example, scientific and economic uncertainty can lead to or compound political uncertainty and inaction. This repositioning of uncertainty as comprising mutually dependent scientific and social dimensions suggests there is merit in refocusing attention towards the relations between different forms of knowledge and their application in practice. Put differently, research has tended to consider uncertainty as a research *subject*, a means to quantify and increase scientific confidence within discrete arenas; however, the implementation difficulties of managed retreat suggest that uncertainty could also be recast as a research *object*, worthy of focus in itself, to better capture its multi-faceted, compounding, and interrelated nature of risk and response. The following sections are designed to advance this reframing and deepen understanding about both the interplay of uncertainties between science and society, and within the various arenas of managed retreat decision-making and praxis. Insights gained by interrogating the Matatā experience may inform managed retreat efforts in other localities in New Zealand and elsewhere.

4. The New Zealand Governance Setting for Managed Retreat: A Gradual Revealing of Multiple Uncertainties

We start our analysis by revealing the various governance uncertainties that were in evidence as the Matatā situation unfolded. In New Zealand, the responsibility for managing the effects of natural hazards and adapting to climate change is devolved to local government. In practice, however, the task is inherently political involving local authorities, elected officials, affected people, sectors, and communities, iwi, banks and lending institutions, utilities, infrastructure and insurance sectors. Primary mechanisms for retreat interventions include provision of information, regulation, incentives and disincentives, and risk transfer, with regulation and incentives being key to deliver action [8]. Managed retreat provisions are present in the New Zealand Coastal Policy Statement 2010, and it is considered, promoted, facilitated, and required in various ways in both regulatory and non-regulatory stipulations [56]. However, in reality, the regulatory framework is not designed to deliver managed retreat, and has no funding to support it [57]. The conceptualization and impact is evolving in response to influences of escalating risk, the consequences of extreme events, information provision, insurance retreat, evolving local policy and regulation, limited use of compulsory or negotiated land acquisition under the Public Works Act 1981 (delivering managed realignment), pilot strategies, and ad hoc government interventions and community actions.

The various retreat options can be conceptualized as situated on a spectrum between strong government intervention on one end and anarchy on the other, where people are left to respond to risk themselves; or in simple terms, from managed to unmanaged retreat [56]. In New Zealand, the decision-making framework for *managed* retreat rests predominantly with environmental planning and the mandated promotion of sustainable management of natural and physical resources under the Resource Management Act 1991 (RMA). However, as there is no single pathway to or any preferred version of retreat, the scope of possible actions effectively fosters an environment of uncertainty, as who is responsible and how managed retreat should occur varies significantly according to context and circumstance.

Under s 62(1)(i)(i) RMA, regional councils delegate the responsibility of land use control for natural hazard management to territorial authorities (i.e., district and city councils) in their respective regional policy statement (RPS) (with general exclusions for the coastal marine area, the beds of rivers and lakes, and some joint responsibilities). Territorial authorities, using district plan controls over land use activities can limit new and re-development (intensification, extensions, additions, and activity status change) in areas subject to natural hazards and the influences of climate change. In addition,

this includes providing for future managed retreat (where appropriate) using relocatable building design with monitoring and review of consent conditions to safeguard and facilitate future relocation. In contrast, while there are opportunities to regulate new land uses and encourage managed retreat over time, where development already exists, territorial authorities have very limited agency as many activities have existing use rights. However, under s 20A of the RMA, if it is within the scope of a regional council's functions, it may be possible to apply regional rules to regulate managed retreat by extinguishing existing land-use rights.

Therefore, whilst managed retreat (as a form of land use control) aligns with delegated territorial authority functions, only regional councils hold powers to enforce it for existing development, creating a jurisdictional problem that generates confusion and uncertainty for practitioners. In an attempt to address this conundrum, three regional councils explicitly recognize the jurisdictional overlap and relevant functions in their RPSs. While these councils have attempted to reduce institutional uncertainty regarding roles and responsibilities, there are still political challenges in practice, as will be discussed in Section 5. In addition, there is a degree of legal uncertainty regarding compensation for regulatory takings (extinguishment of existing use rights) due to a lack of precedent and case law.

Although there are difficulties in achieving managed retreat of existing development using planning regulation, some councils have been able to achieve it using negotiation or compulsory property acquisition under the Public Works Act. However, this approach requires some form of public work, such as a stop bank or sea wall, and is, therefore, more correctly termed 'managed realignment', being a deliberate alteration to, or creation of, defenses, ideally in a way that restores natural space and enhances the capacity to cope with environmental fluctuations [9]. Such property purchases have been occurring to manage inland flooding across New Zealand, for example, in Edgecumbe, Hutt City, and Waitakere, where willing buyer-willing seller negotiations were first attempted with property owners. The powers of the PWA were available to authorities (and declared to property owners) if owners refused to sell [58–60]. However, property acquisition is difficult to achieve without a mechanism (or budget) to acquire land, unless public works are involved and the PWA is invoked. Nonetheless, there is legal uncertainty regarding whether land can be compulsorily acquired under the PWA for the creation of reserves, or whether land is only able to be purchased by agreement [20,61]. In the case study of Matatā, Whakatāne District Council received legal advice that the PWA could not be used for managed retreat and subsequent reserve conversion, but, to confuse things further, the Resource Legislation Amendment Act 2017 (s 85(3A)(a)(ii)) suggests otherwise.

In short, despite managed retreat being possible under prevailing legislative provisions, there is limited national guidance on how to frame and implement it, when, or at whose cost. This is exacerbated by the scope of possible actions, whether site-based and incremental, or those requiring major strategic changes to land use. Such fundamental questions present multiple sources of uncertainty for both policymakers and affected parties. The implications of this uncertain governance framework were gradually revealed in Matatā as managed retreat became a political imperative, that then became subject to compounding uncertainties that essentially demanded a process of policy exploration and learning. This had consequences for both the planning regime and the people living in Matatā, who became the proverbial 'guinea pigs' and bore much of the costs of efforts to resolve the underlying uncertainties. The following analysis highlights the cascade of uncertainties that built up over time within the governance arena and provides insights about the real-world consequences.

5. A Case Study of Matatā: Revealing the Interrelated Arenas of Governance Uncertainty

5.1. Strategic and Institutional Uncertainty

In the wake of the 2005 event, the Whakatāne District Council (WDC) and community embarked on recovery, deciding that for properties on the Awatarariki fanhead, a debris dam was an appropriate risk management response. Fast forward seven years, following much assessment, consultation, expert advice, and peer review, it was determined by WDC that the envisaged engineering structure was not

viable, and would require significant maintenance and consenting programs in perpetuity. Ten years on from the event, and after further technical assessment of alternative risk management measures, it became apparent to WDC that managed retreat was the only remaining option to reduce the risk to human life. Following workshops with a 'consensus development group' and further consultation with the community, cost-benefit and multi-criteria analysis, a 'voluntary retreat package' and property regulation strategy was developed [62].

Due to a technical assessment of 'intolerable' risk to human life from the debris flow hazard, WDC had a responsibility to act and managed retreat became necessary as other options were ruled out. This meant that the various institutional, funding, and practical uncertainties had to be faced 'head on'. WDC had to be creative in its approach. It deemed that a financial incentive was necessary to secure public acceptability, so WDC developed a strategy outside of the statutory regime to offer a property buyout, using general competency powers under the Local Government Act 2002 s 12(2)(a). However, as this incentivized approach was non-statutory, WDC could not enforce it, nor did it have any capacity under the RMA to reduce residual risk and give effect to the RPS if uptake was fragmented. Doing so would have required the WDC to have powers to extinguish existing use rights; powers that are only available at the regional tier of government.

This interplay between state responsibility and powers contributes to a situation of 'strategic uncertainty' [50] whereby governance actors must respond to and anticipate each other's strategic moves. As these authorities have discretion to make their own choices, strategic moves are an intrinsic characteristic of interactions to address composite problems [50]. In Matatā, political acceptance of managed retreat at the district level was gained via early alignment and inclusion in policy development, but there was political resistance from the Regional Council whose powers were being sought to regulate managed retreat (Participant 4). Although the BOP RPS clearly denotes regional powers for extinguishing existing use rights, when initially consulted on the need for a regional plan change, the BOP Regional Council (BOPRC) labelled the proposed managed retreat strategy by WDC as 'draconian'. In the absence of clear national government direction, the BOPRC instead resolved that WDC must prepare a private plan change, which essentially served to transfer their own responsibility to act and reduce their own potential political risk. In this uncertain governance environment, characterized by institutional uncertainties and poor integration, operationalizing managed retreat became a vexing challenge. It is well established that managed retreat, even via less forceful intervention than extinguishment of existing use rights, is socially contentious [2,18,63,64]. The consequent step to extinguish existing use rights in the manner envisaged by WDC was unprecedented in New Zealand which, particularly when devoid of directive national policy, created significant political risks for the responsible local authority actors.

Compounding these risks is the fact that extinguishment of existing use rights produces a new swathe of legal and procedural uncertainties in terms of timing and enforcement for the regulatory authorities, especially in the prevailing circumstances where residents were threatening civil disobedience, including chaining themselves to their homes:

> ... *nobody's got any appetite to be sending in bulldozers with protesters lying on the road* ...
>
> *When I was talking to one of our regulatory compliance team leaders he asked me the same*
>
> *questions—'How do you expect me to get these people out?'. (Participant 5)*

Local authorities may have overlapping responsibilities in dealing with natural hazard risk, but they have different tools, capabilities, and regulatory capacities, which require integrated management approaches. However, it is clear that the uncertainty in governance combined with the institutional risks of action and inaction meant that managed retreat would likely become a political 'hot potato' where authorities engaged strategically and in a siloed manner to avoid getting 'burnt'. Attempting managed retreat of existing land uses in Matatā further highlights how "successive governments and the RMA have provided a high-level policy direction around natural hazard risk reduction without providing any appropriate tools in the toolbox" (Participant 4)—or the capacity to deliver

implementable actions. As such, it is apparent that insufficient attention has been given to designing clear and agreed institutional processes to facilitate managed retreat. Instead, they have evolved in an ad hoc manner, and managed retreat policy development and learning occurs in an uncertain governance environment, devoid of guidance or regulatory mechanisms. One can understand why governance actors were risk averse when the statutory framework does not provide clear direction, nor the necessary tools to enable effective, equitable and sustainable decisions. This situation contributes to 'decision uncertainty' for managed retreat, creating doubt about the appropriate course of action [27], underpinned by a variety of institutional uncertainties that emerge as the realities unfold. Meanwhile, the risks continue to be experienced and even escalate while the dilemma prevails.

5.2. Financial Uncertainty

The discussion so far about managed retreat at the strategic level has set the scene for understanding the contagion of uncertainty, which spreads from arena to arena and back again. Without directive national policy guidance, and regulatory tools for planning and implementing managed retreat, local authorities across New Zealand are "wondering how the hell we do it" [65]. As a consequence of the institutional uncertainties, difficult financial questions are raised regarding whether or not incentivisation and/or compensation is required, to what extent, and who carries the cost? Uncertainty about how to finance managed retreat remains a significant issue for local government [66] (p. 23), resulting in what amounts to hopeful reliance upon potential regional and national funding sources [65]. In Matatā, this too was the case, with the preferred managed retreat strategy dependent on the availability of external funding [62]. The WDC determined that it had a moral obligation to financially support property owners due to their loss of property under voluntary retreat, and recognized that successful retreat invariably depends on the availability of a financial incentive to compensate or provide security to those affected. In the context of governance and funding uncertainty, WDC began having conversations with government ministers and departments to try to pave a way forward. A business case was developed with a proposed tripartite funding model to facilitate property purchase, with central government, the regional, and district council each sharing a third of the costs. As part of its case to regional and central government, WDC highlighted the unique features of the project, stating that it only sets a precedent of an obligation to incentivize retreat where a risk-based approach has been applied with community engagement to manage a situation that has no other viable risk reduction solutions. Moreover, this applies where the assessed risk to human life is intolerable, and the costs to manage the risk are beyond the fiscal capability of the local authority to manage [62].

While WDC had no confirmation that funding would be provided by the Government or regional council, they proceeded with delivering an indicative buyout to property owners on the basis that funding agencies require certainty around the financial exposure, and are "unlikely to provide funding support if there is a risk of becoming embroiled in an on-going dispute" [67] (p. 5). In December 2016, preliminary offers were given to property owners at individual meetings including a non-binding registration of interest to indicate whether or not parties wished to participate further. The proposal reflected an indicative offer based on the current market value of properties without accounting for the hazard, conditional upon funding support from Government and BOPRC. The purpose of undertaking the valuations at this time was to define the potential financial envelope to enable meaningful dialogue between the proposed funding agencies. This option was deemed as being voluntary, outside of the regulatory regime. However, residents were made aware that the proposal was on a one-time offer basis and that the BOPRC had statutory authority to extinguish existing use rights if the buyout was not successful.

WDC was intending to deliver the property buyout before regulatory measures came into effect, but advice from the local Member of Parliament (MP) at the time was that the government wanted to "see some attempt from the district council around the plan changes" so WDC proceeded with preparing these provisions (Participant 4). However, initiating regulatory processes at the same time as the 'voluntary' buyout did not engender trust, particularly as the extinguishment of existing use

rights would remove property owners' choices (notwithstanding Environment Court appeal or civil disobedience) should they wish to stay. Myatt, Scrimshaw, and Lester [68] argue that where there is trust in governance actors, a more positive attitude towards policies such as managed retreat can be expected. For such provisions to be perceived as legitimate, institutional trust is required, which takes time to develop and can easily be lost. Residents who did not support managed retreat in Matatā apparently did not trust local government, in part due to the previous changes associated with policy experimentation and the parallel discussions. They expressed very strong opinions: "no, not at all ... They give us the right to live here and then they take it away. This is why there is no confidence in the Council" (Participant 8). Participant 10 recognized that this trust was "gradually eroded" stating, "there's just so many lies. The trouble is people have changed ... the ones that are in there now have no idea of what they had done prior." Long-term uncertainty, staff turnover, and policy inconsistencies (especially the change from hazard mitigation to managed retreat) stem from an uncertain institutional and financial environment, and contributed to mistrust in the Council by some affected residents.

The situation WDC faced, attempting to progress managed retreat under conditions of strategic, institutional, and financial uncertainty, cascaded into the social sphere, particularly residents' lack of faith in the Council and their intentions:

> *Participant 10: It's bogus! Because there's no money to back it up!!*
>
> *Participant 9: There's no trust there at all ... I mean they made us all these offers for the houses, but they've got no money. So, they're not really offers at all.*

Further loss of trust occurred when WDC changed their policy regarding the thresholds for uptake of voluntary retreat. In 2015, they determined a 90% acceptance threshold would be required to approach external funding agencies, but in 2017 it was decided that "a threshold should not apply as it could potentially disadvantage property owners who wanted to relocate" [69] (p. 13). Many residents considered this a deliberate manipulation of the process as WDC had initially placed high significance on the threshold.

Residents who were more accepting of managed retreat trusted WDC staff and considered that the key staff and experts had "acted in good faith". However, they were not so trusting of Councilors at both WDC and BOPRC, feeling disappointed that some had not shown stronger leadership to resolve matters in preceding years of uncertainty and limbo. Regardless of the trust that some residents had in council staff, they too were beginning to have doubts, stating that they thought the process had been mostly fair and transparent, but that the timing of the regional plan regulation made it difficult: "are we being naïve, are we trusting them too much?" (Participant 16). Even those who maintained a trusting relationship with the authorities were feeling nervous about potential extinguishment of their rights without 'fair' compensation—or any compensation at all.

5.3. Cascading Spatio-Temporal Uncertainty

Since 2005, a governance regime riddled with compounding uncertainties has generated a cascading effect on people's 'ontological security' [70] (p. 92), with normally settled issues of property, place, and livelihood disrupted. The debris flow was like nothing the residents had ever experienced. A house was lifted off its piles and one family sailed on a treacherous slurry of silt, mud, boulders, and logs. They climbed up into their roof as their house plunged back and forwards, holding on for dear life. Others escaped their homes just in time, and a few watched in fear as the currents of debris swept through. Some residents were displaced for periods of nine to 18 months, living out of suitcases, in a state of limbo [71]. Two years after the disaster, many had no certainty regarding their living situations, and felt more stressed, frustrated and upset than in the first few weeks following the event [71]. Psychological impacts recorded included sleeplessness, stress, anger, anxiety, vulnerability, sadness, isolation, and depression [71]. Spee described the impacts as being reflective of a community that felt overwhelmingly powerless, stuck in a cycle of agitation, tension and sadness, a festering wound of anger and hurt [71].

Many residents who experienced the event still experience these health impacts 13–14 years on. Participant 11 said she has post-traumatic stress disorder and feels extreme anger towards the authorities: "What I feel, is they have minimized what happened to us all along, it's been minimized and swept under the carpet—'oh you fullas are all right now, get over it, move on.'" Participant 10 says "it's been stressful the whole time" holding a deep-seated sense of anger and disappointment at the way they have been treated. Others recognize the ongoing stress that has been inescapable for everyone:

You're under stress . . . You can't sort of get away from it. (Participant 9)

Look I've watched people have heart attacks . . . [people] taken, put into rest homes that they didn't want, marriages split up, because it's constantly there, it's always there. (Participant 10)

Many property owners living on the fanhead have felt trapped in houses that hold their life savings, unable to move on, or unwilling to do so. Others took action. Between 2006 and 2012, six houses were rebuilt on the basis of a proposed mitigation solution that did not ensue, with others improving their properties during this time. Extended uncertainty contributed to a continued state of stress and trauma for many, and for those who rebuilt and re-invested, an even greater intensification of economic stress. Some feel that they have not been able to recover from the event, finding the added burden of the planning process and impending loss of property rights extremely stressful:

Participant 8: The thing is, it's on your mind all the time. Because it takes your time, because you're constantly fighting them, constantly looking up things to find out about it, it's your family home, it's everything you've got, invested in it.

Participant 9: I'm on the pension, I haven't got any other money, it's all here. If I get kicked out with nothing, where am I going to go, what am I going to do? I don't get enough money to rent a place and survive, I can't get a mortgage . . .

Participant 13: I'm stressed . . . I drink like a fish, I've put on that much weight you know . . . I don't sleep.

The impact of extended stress is not only health and resilience related. It breeds anger at the situation people have been left in and their lack of agency:

Participant 14: We're being dictated to . . . I won't move because this is where I chose to live out my life. We're all happy . . . nobody wants to leave . . . If offers had of come out in 2005 and were reasonable, people would've taken it. But it's 13 years down the track.

After being in this situation for many years, resistance to council efforts built up, a 'digging in of the toes', triggered by erosion of trust and feelings of disempowerment. The affected residents of Matatā have been experiencing spatio-temporal disruption, where their futures remain "stalled and fixed in uncertainty, ultimately influencing notions of belonging and urban governance" [72] (p. 755). Without enabling mechanisms, policy direction or confirmed funds to deliver an effective, legitimate strategy, managed retreat is considered to be a precarious 'solution', made worse in this case by delicate trust issues, stirred by a drawn-out recovery and changes in approach—a compounding and cascading plague of uncertainties that has spread between policy arenas. While funding was confirmed in 2019, the extended period of limbo, perpetuated by governance uncertainties has cascaded into years of "permanent temporariness" [73] (p. 90) significantly damaging trust, legitimacy, and faith in authorities, in technical risk assessments, and in managed retreat. Resistant residents have resorted to doing anything they can to avoid placelessness, from collaborative research, submissions, outreach and legal defense, to media releases, petitions, signage, and even threats of civil disobedience, highlighting the extent of their determination to remain in situ after all they have been through, and despite persistent risk.

For others who are more trusting of the process, or less able or less motivated to resist managed retreat, their spatio-temporal disruption is no less, because while they have begun to loosen their

current ties, they are struggling to form new ones and embrace an uncertain future. Participant 16 recognizes that while the offer is better than nothing, residents have limited capacity to re-settle:

> *"The indicative price they offered us might've seemed like a good price, but it would be about $80,000-$90,000 to shift our house ... first you've got to find a piece of land to put the house on ... it would probably gobble up absolutely everything ... we are very worried ... it's a major headache."*

Furthermore, uncertain land availability for relocation raises new unresolved governance questions, potentially limiting the affected communities' ability to maintain community, psychological, and livelihood networks. Participant 16 stated they would have been keen on a land swap "because land is the hardest thing to access" for physical, planning, and economic reasons. But the question of 'managed retreat to where?' has been left for individuals to manage, and there are concerns regarding the impacts on social, cultural, and economic vulnerability, where capacity is already limited. This highlights the importance of strategic clarity to establish a range of relocation opportunities when delivering managed retreat. WDC had undertaken some research to determine the potential for future growth to the east of Matatā, and the impacts of intensification upon the town sewerage system [62]. However, residents, especially those intended to accept the buyout, want to be able to ascertain property options and have certainty about their prospects in the near future.

Even at its most effective, managed retreat is still a disruptive social process. However, when governance uncertainties compound and cascade upon affected people, they experience mounting stress, 'routine waiting' [72], and fear the future. There are also multiple layers and sources of place attachment, which may be affected by uncertainties for any given relocation. In Matatā, this is particularly relevant, as there has been long-term occupation by Māori, and the Awatarariki catchment and fanhead is of considerable cultural importance. In the 1980s, initial development of the fanhead was strongly opposed by local Māori due to the presence of an historic burial ground (urupā); however, their appeals were disregarded due to inconclusive evidence [74]. When the earthworks began, many bones were unearthed:

> *... they just came up everywhere. Every week, the kaumātua (elders) of the time were taking them up to the urupā and [re-]burying them ... It was a big mess, but then it just carried on .... (Participant 7)*

Disregard of indigenous knowledge, due to the focus on scientific rationality resulted in the destruction of tapu (sacred) sites and a sense of long-term local iwi concern and uncertainty about the protection of cultural sites. Following the 2005 event, Tūwharetoa kaumatua (Māori elder) believed that their ancestors were angry at the disturbance, with much of the debris flow damage being in areas where ancestors were killed and buried [75].

> *A lot of us said, 'that's the ancestors, even the ones up in the valley, covering over' ... the whole place is super tapu ... because that's an old urupā ... So on my Māori side I'd like to see them move out because it needs to be left alone. We weren't even in favor of them building there, of course we wondered why they went back [re-building post 2005]. This debris has come down to bury the urupā once and for all. (Participant 7)*

Although current residents face spatio-temporal disruption, managed retreat could eventually enable local iwi to regain certainty of their guardianship over sites of significance, provided the appropriate planning controls are in place. With such experience of cultural dislocation and insecurity over time, Participant 7 considered that the *regulatory* approach to managed retreat is "heavy handed", believing that the residents should be given a generous offer to support their detachment, to ease the stress by providing financial certainty. Whilst, in this case, managed retreat has the potential to deliver some cultural security with regard to guardianship of the urupā, in other locations across New Zealand, climate change is exacerbating erosion and flooding of urupā and marae (Māori meeting house) [76] with the same uncertainties regarding "where, when and how it [managed retreat] would be funded" [77] (p. 1). Again, this governance ambiguity is compounded by distinctive cultural concerns in Aotearoa New Zealand:

Exhuming the bodies is a last resort. That discussion is quite hard. It is such a tapu process, and trying to source land and resources makes it even more difficult. Olo-Whaanga, S in [77]

　… We need a new protocol for how we are going to deal with the urupā that need to be shifted, because Māoridom is not going to be able to cover the extraordinary costs … Awatere-Huata, D in [77].

6. Discussion

In the case of Matatā, compounding and cascading uncertainties spread like a contagion and exacerbated the managed retreat dilemma. In the first instance, without a clear risk reduction and strategic recovery response framework to direct decision-making following the 2005 debris flow, WDC and the community became focused on absorptive resilience, seeking to bounce back from the extreme event, settling on a risk mitigation rationale when, in hindsight, managed retreat was the only viable option to deal with the ongoing risk to life. While the hazard mitigation method initially proposed provided fleeting assurance, this short-term certainty was traded for longer-term uncertainties and stress as the managed retreat imperative came to the fore, and implementation became fraught.

Developing and implementing a managed retreat strategy without adequate policy guidance, regulatory tools and funding provisions is nigh impossible. To enable managed retreat within the prevailing planning system, fit-for-purpose mechanisms and national support and policy provisions are necessary to provide direction, enabling institutional capability, and surety to affected parties, and the decisionmakers and practitioners responsible for managing retreat, and to reduce cascading political, financial, institutional, cultural and social risks. Managed retreat is not a cheap undertaking, requiring funds for risk assessment, community support and engagement, strategic planning, policy development, disestablishment of development and restoration of land, not to mention potential financial incentives and associated property valuation and negotiation processes. Limited local government capacity to attain funds to reduce technical uncertainty [4], let alone undertake strategic, anticipatory adaptation and risk reduction planning, means that managed retreat is laden with risks for councils. Funding clarification is necessary to ensure legitimate, incentivized managed retreat, and to balance the social costs of relocation. Jones and Clark [78] confirm that perceived social costs and benefits of policies influence levels of public acceptability, and that social capital parameters, including institutional trust, also have an impact.

Trust is important to achieve successful cooperation within and between spheres of government and communities at risk under conditions of uncertainty [50]. It is an important feature of social capital, developing from relationships based on belief in the care, honesty, and good faith efforts of others, which can mitigate risk, and help address vulnerability based upon positive expectations of the intentions or behaviors of others [79,80]. In attempting managed retreat, trust is essential, and is particularly delicate when actors are highly vulnerable to harm from intervening authorities. Koppenjan and Klijn [50] recognize that inconsistent actor strategies and changing circumstances may negatively affect trust, as was also revealed in this case study as residents' trust in authorities was diminished as a result of compounding and cascading governance, funding and socio-cultural uncertainties. While trust can help to overcome uncertainty [81], when uncertainties are compounding and pervasive, trust between communities and their governing authorities may be undermined, reconsidered or dwindle altogether [50].

In Matatā, the local council had to overcome many challenges to arrive at and deliver managed retreat in the absence of a guiding governance framework, regulatory tools and funds. The process of policy experimentation and learning resulted in contention between some of the residents and local government, enduring trauma, and stress for the community and staff involved 14 years on from the debris flow. While regional and central government agreed finally, in 2019, to co-fund the buyout, the ad hoc approach to managed retreat policy and funding are disruptive and inequitable, and create reactive strategies that are consistent with a fragmented risk management. These compounding uncertainties challenge the realization of managed retreat and increase the potential for cascading social costs and accumulating mistrust, aspects that may not be resolved by measures designed to increase

scientific certainty. The prospect of uncertainty contagion is not limited to Matatā. Many other New Zealand communities, such as Mōkau, Marokopa, Kaiaua, Franz Josef, South Dunedin, Port Waikato, Hector, Ngakawau, and Granity, face similar challenges. Internationally, these multiple uncertainties associated with managed retreat also compound and cascade and hamper effective action [1,17,82].

This paper has revealed multiple arenas in which uncertainty about managed retreat becomes manifest, and outlines how it spreads between what are very different albeit interconnected domains, from technical risk, to the governance arena with its funding and legal ramifications, to public acceptability, and the socio-cultural and political arenas. Significantly, we argue that to address the uncertainty contagion, the different arenas of uncertainty need to be revealed, and 'joined up' responses are required by different actors within different networks. The potential for multiple, cascading and compounding uncertainties underscores the inherent difficulty of enacting managed retreat in a coordinated fashion. There is an arena of scientific or technical uncertainty, where quantification is often invoked in efforts to clarify and contain the scope of uncertainty, or which receives new demands for authority in response to political or social uncertainty. There is an arena of governance uncertainty, where politicians, policymakers and practitioners, and governance actors more generally, clamor for clarity on direction, process and responsibilities. There is an arena of political and economic uncertainty where decisionmakers and communities strive with each other to secure agreement regarding compensation or incentives (not to mention potential damage claims and reparation [83]). Finally, there are arenas of social and cultural uncertainty, where communities and individuals reflect upon and interact with others about their values, needs, and ethics associated with their connection to place and each other, their trust in authorities, and their willingness to accept or resist managed retreat. While a discussion of taxonomy is useful in demonstrating the scope of the challenge, we argue that the way that uncertainty spreads between domains means that a relational understanding of uncertainty needs to be developed to better comprehend and address the managed retreat dilemma. For example, in Matatā, governance uncertainty compounded political uncertainty, which was further compounded by financial uncertainty, which eroded public trust in both authorities, the underlying science and local government strategy. While, in situations like these, there may typically be a call for more technical data to increase scientific certainty and reduce political risk, it is clear that, on its own, this response would not reduce the considerable uncertainty manifest in other domains. Further, new dimensions of uncertainty may yet be discovered. For example, in New Zealand, attachment to place differs within and between Māori and other cultural groups, and much remains to be done to build shared understanding and enable tikanga Māori (customs) for retreat from Māori land.

7. Conclusions

The potential of managed retreat is hampered by concatenated uncertainties that can only be addressed if they are identified [27], but they also need to be considered in relation to each other and addressed across different arenas—from the techno-scientific to governance, financial, spatio-temporal and socio-cultural—in a coordinated manner. The Matatā experience demonstrates that, in the absence of strong policy direction and 'joined up' praxis, uncertainty can spread like a contagion. Our perspective offers a new frame to understand the considerable difficulties experienced in implementing managed retreat in New Zealand and potentially elsewhere. While governance frameworks, and economic and socio-cultural settings inevitably differ, there is noteworthy commonality in the intersecting layers of scientific, institutional, financial and social uncertainty that bedevil managed retreat efforts in divergent settings from Alaska [5] to Australia [16,18,21,23] and New Zealand.

More broadly, our perspective highlights the value of conceiving uncertainty as a distinct research object in itself. Regardless of the context within which managed retreat is applied, there will inevitably be both scientific and governance uncertainties in evidence, such as the level of natural hazard risk and the level of political risk associated with questions such as how managed retreat is to be applied, by whom, at whose cost, when, and to where? Policy learning is occurring to progress managed retreat, but its socially disruptive nature means that every trial counts. At present, managed retreat

interventions are professionally, politically, financially, culturally and socially risky, as the necessary frameworks and resources are seldom in place to support effective, equitable, responsive, and robust decision-making. Uncertainty over governance essentially means that these risks persist and, as such, may compound future risks, whether due to maladaptation or inability to adapt due to limited capacity to enable managed retreat. While managed retreat holds potential as a risk reduction approach, without acknowledging how scientific, governance, financial, political, spatial and socio-cultural uncertainties are entwined, and require distinctive but coherent strategies, the managed retreat dilemma will prevail.

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