resources

MDPI

Article

A Participatory Process to Develop a Landslide Warning System: Paradoxes of Responsibility Sharing in a Case Study in Upper Austria

Philipp Preuner [1,*], Anna Scolobig [2], JoAnne Linnerooth Bayer [1], David Ottowitz [3], Stefan Hoyer [3] and Birgit Jochum [3]

[1] Risk and Resilience Program, International Institute for Applied Systems Analysis (IIASA), 2361 Laxenburg, Austria; bayer@iiasa.ac.at

[2] Climate Policy Group, Department of Environmental Systems Science, Swiss Federal Institute of Technology (ETH Zurich), 8092 Zurich, Switzerland; anna.scolobig@usys.ethz.ch

[3] Department of Geophysics, Geological Survey of Austria (GSA), 1030 Vienna, Austria; david.ottowitz@geologie.ac.at (D.O.); stefan.hoyer@geologie.ac.at (S.H.); birgit.jochum@geologie.ac.at (B.J.)

* Correspondence: preuner@iiasa.ac.at; Tel.: +43-660-6410008

Received: 18 August 2017; Accepted: 28 September 2017; Published: 3 October 2017

Abstract: During a participatory process in Gmunden, Austria, the organizational and responsibility-sharing arrangements for a landslide warning system proved to be contested issues. While questions on the warning system technology and the distribution of information, including the alarm for evacuation, could be resolved with the support of experts, controversies arose on the financial and legal responsibilities that ensure long-term and effective monitoring for the protection of the landslide-prone community. This paper examines how responsibilities can be shared among the residents, experts, and public authorities during the design and operation of landslide warning systems. In particular, we discuss the outcome and implications of three stakeholder workshops where participants deliberated on warning-system options that, in turn, were based on a discourse analysis of extensive stakeholder interviews. The results of the case study show that an end-user orientation requires the consideration of stakeholder worldviews, interests, and conflicts. Paradoxically, the public did not fully support their own involvement in the maintenance and control of the warning system, but the authorities promoted shared responsibility. Deliberative planning does not then necessarily lead to responsibility sharing, but it proved effective as a platform for information and for shared ownership in the warning system.

Keywords: warning system; landslide risk; technical-policy option; responsibility sharing; public participation; stakeholder perspectives; warning communication and decision making

1. Introduction

This paper describes a participatory approach for the design and operation of a landslide warning system. Stakeholder participation in disaster risk reduction has attracted attention in discourse and practice, with proponents arguing that it improves effectiveness through ownership and shared responsibility [1–4]. A participatory and people-centered approach links hazard monitoring and risk communication closely to vulnerability and considers enhanced preparedness as a key component to guarantee the effectiveness of warning systems. A people-centered approach has recently been endorsed by the Sendai Framework for Disaster Risk Reduction 2015–2030 which "comprises four key elements: knowledge of the risks; monitoring, analysis and forecasting of the

hazards; communication or dissemination of alerts and warnings; and local capabilities to respond to the warnings received" [5].

In this paper we focus on the contested question of responsibility sharing for landslide warning systems based on empirical results from a case study in Gmunden, Austria. While addressing the research gap pertaining to social, economic, and institutional features of landslide warning systems described above, we demonstrate the importance and contestation of responsibility sharing, including (1) financial responsibility for the costs of the system and maintenance; (2) system responsibility for assuring that the system is designed, built, and maintained; and (3) information responsibility for ensuring regular information and timely warning. A major question during the design process of the warning system was how these responsibilities could be shared, and the legal basis for this sharing, among experts, political representatives, and the public; and, more generally, the reasons and implications of including stakeholder views for participatory design and operation of warning systems. In this paper, we discuss both the process and policy outcome of the participatory experience in Gmunden. This is relevant because public participation requires well designed procedures and methods in order to avoid inefficiencies such as reproduced power distributions or prolonged planning processes [6–12]. We build on previous research [1,13] that demonstrates the usefulness and applicability of participatory processes to forge a compromise solution for disaster risk reduction measures. In Gmunden, based on a discourse analysis and subsequently developed options of a landslide warning system, a compromise solution was reached. While briefly describing the most accepted technology mix and degree of information, the paper is focused on responsibility sharing in the institutional context of Austria.

In the following section we provide a literature review on participatory approaches to landslide risk reduction. In Section 3 we present the the case study and policy context in Gmunden, including the major disagreements among stakeholders. Subsequently, we explain the research design and participation methods that were used to elicit stakeholder discourses and reach a compromise solution, including how the responsibilities for the warning system were shared among the residents, authorities, and experts. The results of the process will be discussed in another section, which is structured along the discourses/options and the main controversies/dilemmas that evolved during the deliberative process. The final section concludes with a discussion of the possible reasons for the outcome in Gmunden as well as the implications and applicability of the responsibility sharing of landslide warnings.

2. Background

Social science research to advance warning systems and emergency management has generally focused on warning dissemination and communication [14–19] rather than on the involvement of stakeholders in the design and operation of the system. While risk communication is a central component of warning systems, the understanding of stakeholder views on warning systems (problems, solutions, alternatives) and the integration of technological, societal, economic, and legal considerations in the design of warning systems have received relatively little attention [20,21]. This integration can be facilitated with a participatory process. Mees and colleagues [22] suggest that a participatory process for the design of the warning system should be complemented with shared responsibility among the authorities, the expert community, and the end-users for the operation and maintenance of the system. Although participatory processes are not new in environmental and natural hazard policymaking [23–29], they have been rarely applied to landslide warning systems. There is a lack of guidance on how to design inclusive processes that involve stakeholders and experts for the purpose of co-producing knowledge for the establishment of warning systems. One reason for this gap is the rapid innovation in warning system technology that has led to expert-driven systems with far less attention to their social, economic, and legal dimensions. While participation is a legal standard for the design of flood protection in Austria, there is no such a component in the official procedures for landslide risk reduction measures. As a consequence of this novelty, efforts to involve stakeholders in the development of warning systems prove to become community-based, participatory research projects. While the strength of involving communities in

risk mitigation efforts is their ability to assess needs and distribute goods and services, such an involvement can also undermine the independence and autonomy of community organizations [30].

The advantages of participatory approaches for warning systems include the potential for their improved design and long-term operation, as well as enhanced awareness of the operation of the systems, which is particularly important for hazards like landslides that occur rarely. Experience has shown that trust-building and community development are key to eliciting new options and creating a broader base of shared responsibility [31–33]. Recent research has shown that failed risk management cases, such as misinterpreted warning data and insufficient communication, with legal consequences for practitioners (e.g., the case of the aftershocks to the earthquake that hit L'Aquila, in Central Italy in 2009, where earthquake experts mistakenly advised residents to return to their homes combined with lacking earthquake preparedness [34,35]), can lead to the reluctance of politicians and experts to take responsibility. Such cases show that warning dissemination and communication are highly entangled with the institutional design of the warning system. The duties, responsibilities, and liabilities that accompany the implementation and maintenance of warning systems need to be clearly delineated between public authorities, experts, residents, and other stakeholders in order to protect citizens [36–38]. The success of participatory processes depends on their careful design and management, preventing the threat of stabilizing existing power distributions. Furthermore, it is essential to pay attention to the legitimacy for non-participants, as participation must be limited to a manageable number of participants [13].

Public authorities increasingly promote responsibility sharing, local participation, and people-centered approaches, partly, and importantly, because of their limited capacity to fully implement disaster risk reduction [2]. The case of wildfire in Australia is illustrative of how the guarantee of protection cannot always be provided only by authorities. Sharing responsibility (by means of a triage process to determine the priority for actions based on the severity of the conditions of the people or the area suffering a fire) is viewed as an appropriate form of response to wildfire due to the lack of resources that might be drawn on to guarantee a fair and equal level of protection to all citizens (ibidem). Also, France witnessed a development in the same direction with the 2004 Act on the Modernization of the Civil Security, which stipulates that "citizens are responsible for their own safety" [22]. However, citizen responsibility may be difficult to implement because of the prominent hierarchical state-citizen relationship. This is a key issue in the research reported here.

3. Case Study and Policy Context

The study site is located along the eastern shore of Lake Traunsee and belongs to the municipality of Gmunden. Because of the geological preconditions, the site has experienced regular landslides, reportedly since the 15th century. Gmunden has approximately 15,000 inhabitants, of which about 100 live in and around the landslide-prone area and are directly or indirectly at risk. Approximately 55 buildings are in the risk area, which is popular among tourists. Most properties in the high-risk area are private and were built before landslide risk was delineated by a danger zone in the land use plan in 1987 by the Torrent and Avalanche Control (WLV), an Austrian federal authority. This plan prohibits buildings and new settlements in the high-risk area, taking into account landslide risks, flood debris, accumulation, and river excavation. The most recent landslide event took place in 2007, with an evacuation of the whole area. This event might have been triggered by high precipitation and long lasting snow cover that drenched the underlying marl [39], and the massive rock fall that put additional weight on the slope [40]. The instant measures taken included removing woodland, laying drainages, and installing dehydration wells. Later on, landscaping and preliminary monitoring was undertaken. Most measures were taken by the Torrent and Avalanche Control and funded by the Austrian Disaster Relief Fund, with co-funds from the Federal Province of Upper Austria and the Municipality of Gmunden (see Figure 1 for a stakeholder overview based on a political economic stakeholder identification by Gamper [41]). Although a warning system was a legal condition for the resettlement after the evacuation period, no agreement could be found on how to design and finance it. The starting point for our fieldwork in 2015 was a proposal that had been rejected by the municipality a few years earlier [42].

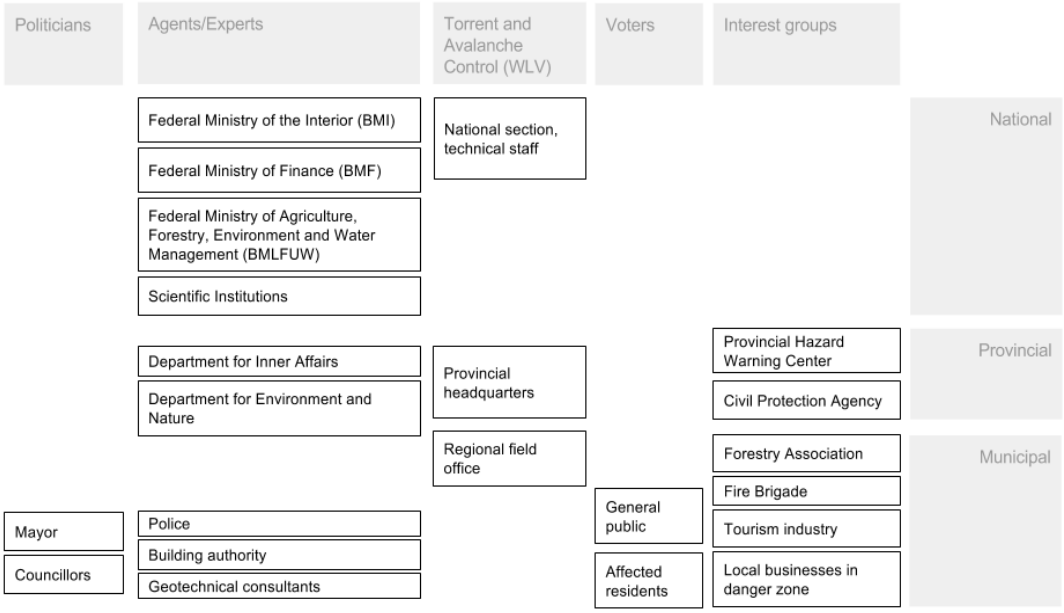

Figure 1. Stakeholder overview.

A main reason for the rejection was the inclusion of monitoring devices for scientific purposes, which was not accepted by the municipal authorities who wanted to pay only for the most necessary technology for warnings. This disagreement about the purpose and scale of monitoring technology was fueled by distrust between politicians and experts that evolved during the emergency management in 2007. According to the municipal geologist, the 2007 landslide had been predicted but the warnings were not taken seriously [43]. Since that time, unclear system responsibility for the maintenance of remediation measures has hampered cooperation between the involved public institutions. Disagreements on what is necessary for a warning system can also be attributed to differences in risk awareness and perceptions among the residents. For example, those who view the risk as high tend to demand more protection than those who have lower perceptions of the risk [44,45].

We use the term "residents" for citizens who live in the landslide danger zone and "general public" for citizens of the same municipality who do not reside in the danger zone. Residents are socio-economically and culturally heterogeneous, and personal conflicts have created a low sense of community. According to a civil engineer who has consulted the municipality since many years, the landslide in 2007 led to strong social cohesion but, years later, conflicts between neighbors recurred (A08). The relationship of the residents to the municipal and other public institutions ranges from high reliance and trust to distrust and strong skepticism. Some residents still have not signed a permit allowing authorities to enter their land for maintenance works, which hampers the public institutions' disposition towards those and other residents. This distrust between the involved public institutions and residents derives from political and administrative issues, rather than the landslide. Everyone agrees that the emergency management in 2007/08 was satisfying. The unwillingness of some residents to cooperate clashes with the plans of the municipality and the Torrent and Avalanche Control to partially devolve system, financial, and information responsibility to residents. Thus, the question whether authorities or the most affected households and businesses should be responsible for landslide risk mitigation and the warning system is a major disagreement. This disagreement manifests in two issues: who pays for the warning system (financial responsibility) and who is responsible for its functioning (system and information responsibility)?

The municipality is facing increasing difficulties in raising financing for the system, which has become controversial, since the general public are asking why the municipality should pay for the protection of about 100 residents out of 15,000. The Austrian tax system is relatively centralized and

rather egalitarian in its use of funds, and, already, 13 million Euro for remediation measures are covered by national and municipal taxpayer funds. The issue is whether the municipality or the small group of benefitting residents should contribute additionally. In Austria, the mayor of the municipality is responsible for hazard protection and emergency management, and therefore for the implementation of a warning system. In line with public participation policies of the Austrian Ministry of Agriculture, Forestry, Environment, and Water Management, it is the intention of the municipality to delegate responsibilities—especially concerning the maintenance of the warning system to residents and other owners of property in the danger zone. Using the terminology of Bretton and colleagues [36], the municipality can devolve functional duties to selected citizens who benefit from a specific measure within the mayor's goal-setting duty to ensure the protection of the citizens. There is a legal basis available both for sharing financial and system responsibility (see below). In the case of the most endangered area in the municipality of Gmunden, a financial contribution by the owners of property in the danger zone became a contentious issue among residents, a restaurant owner, and the Austrian Federal Forestry that owns land in the area.

4. Research Design and Participatory Process

The case study was structured into three main phases: analysis, participatory process, and dissemination (see Table 1). Building on the results of the analysis phase, the subsequent participatory process aimed at reaching a compromise solution for an integrative warning system and included the dissemination of the discussion's outcome.

In the analysis phase, through the methodological triangulation of reviewing policy documents, media, and literature, as well as interviews in 2015 and 2016, we elicited discourses on the technical, social, economic, and institutional aspects of a planned warning system in Gmunden. For the desk study, we collected data from different sources including census (to collect demographic information), municipal archives (to collect information about the landslide), legislation, newspaper articles (archives from the local newspapers Salzi.at, Tips and OO Nachrichten have been consulted), and regional and municipal policy documents. Sixteen interviews were conducted with twenty-one persons including representatives of the municipality, the Torrent and Avalanche Control, civil engineers, geologists, the fire brigade, the police, the Austrian Federal Forestry, and residents. To select the interviewees, we used a snowball sampling technique, i.e., a non-probability technique where existing interviewees recruit future ones from among their networks. We used the methodology of discourse analysis [46–48] to develop warning system options, as described in detail in the accompanying paper "Warning system options for landslide risk: a case study in Upper Austria"[45] (in this Special Issue).

The theory of plural rationality (also called cultural theory [48–55]) served as a heuristic and conceptual framework for the discourse analysis. This theory postulates that stakeholder views or rationalities are plural but limited in number. The rationalities stem from different social contexts, which, in turn, are shaped by the ways in which people organize, perceive, and justify their social relations. According to the theory there are four main rationalities: individualism, hierarchy, egalitarianism, and fatalism (for a detailed description see [45] in this Special Issue). Stakeholders inclined toward the individualistic perspective tend to focus on tradeoffs between costly warning systems and other competing uses of public funds (requiring attention to cost and benefits). Stakeholders inclined toward the hierarchical perspective tend to rely on authorities for warning-related decisions, which they feel can be made most effectively from a top-down approach. 'Egalitarians' tend to take a critical and moral perspective, and are inclined to view technical fixes—such as warning systems—as the problem and not the solution. If a warning system is deemed necessary, they value resident engagement in its design and operation. Finally, for 'fatalists', nature is unknowable and unpredictable and there are few possibilities to control, for example, by means of technical devices.

Our data analysis yielded three main discourses related to warning systems, which roughly reflect the individualist, hierarchical, and egalitarian perspectives, respectively: (i) a minimal-cost warning system; (ii) a technical-expert warning system; and (iii) a resident-centered warning system.

We found little trace of the fatalist perspective among those stakeholders actively involved in the warning system issues, and for this reason we focus only on the remaining three policy active discourses. We designed warning system options informed by each discourse. These options were the basis for the second phase of the research—the participatory process—which consisted of three stakeholder workshops in 2017. Each provided a deliberative platform for information sharing and ultimately reaching a compromise solution. The discourse formulation helped to reduce the stakeholder positions to a manageable number (see Section 4 and Table 2). Thus, the 'minimal/cost', 'expert-driven/technical', and 'resident-centered' options differ mainly by their technological composition, information policy, and responsibility distribution.

Table 1. Research phases.

Phase	Aims	Methods
Analysis	Elicit stakeholder views, and develop warning system options	Desk study (collection of data from different sources including cencus, municipal archives, regional and municipal documents, legislation, and newspaper articles) 21 semi-structured interviews, construction of discourses based on the heuristic/conceptual framework of plural rationality, design of options informed by the discourses
Participatory Process	Reach compromise solution for an integrative warning system	Stakeholder workshops, summary and feedback rounds
Dissemination	Share information with non-participants and the wider public	Distribute recommendation document to participants and municipal authorities, presentation at seminars and conferences

Workshop participants were invited officially by the mayor's office, including experts, civil servants, and residents. The participatory process was open to all residents of the danger zone, and, not surprisingly, those directly affected during the landslide in 2007 were the most interested in participating. Thirty-five persons registered, of whom five were representatives from the municipality (building authority, councilors, geologist), two from the fire brigade and police, one from the provincial government (geological department), two from the Torrent and Avalanche Control, and one from the Austrian Federal Forestry, as well as two private geotechnical/legal consultants and three experts from scientific geological/geotechnical institutions. The remaining registered participants were residents, many with a secondary residence in the area. Due to the limited number of participants that stakeholder workshops can effectively accommodate, we decided not to include the general public, or, respectively, taxpayers, who are not directly exposed to the landslide risk.

To structure the participatory process phase, we relied on the guiding principles of saliency, credibility, and legitimacy at the science policy interface [56]. This means that the information provided is relevant and understandable to all participants while keeping scientific credibility by inviting experts and guest speakers. At the same time, the process was designed in a transparent and inclusive way, for example, by providing information and the opportunity to contribute between workshops. Using diagrams to show the results of the analysis phase and a round-table setting in the museum of Gmunden, stakeholders were presented with the current situation and the warning system options at the first scientist-stakeholder workshop [57] and subsequently asked to choose the option for which they most identified. The consecutive workshops aimed at the co-design of a compromise solution. This was operationalized through a focused discussion of points of agreement and disagreement, as well as the formation of working groups on key and contested aspects of the system. The subsequent round-table discussions aimed at strengthening understanding of the dimensions of a warning system and at creating a discursive space among stakeholders. Based on the recorded discussions and the feedback to written summaries that were disseminated after each

workshop, stakeholder preferences and opinions could be identified and discussed. Sections 4 and 5 describe the results of the workshops.

Finally, the third dissemination phase aimed to share information with non-participants and the wider public. The activities included the preparation of recommendations for the participants and the municipal authorities, and the presentation of the project results at seminars and conferences.

5. Results: Discourses, Dilemmas, and a Compromise

The following sections describe the stakeholder discourses in Gmunden and the essentials of the outcome of the three stakeholder workshops. They show that reaching an agreement was more straightforward on topics of technology and information than on topics of responsibility sharing, especially financial and system responsibility (see Section 1 for definitions). Whether the municipality or the at-risk resident community should bear responsibility emerged as the main and most contentious dilemma resulting from the stakeholder discussions.

The first workshop revealed and clarified misunderstandings concerning the cost, timeline, and purpose of the warning system. It aimed at providing a base of knowledge about the past events and actions to strengthen the understanding of critical issues and cross-sectoral problems of local landslide risk management and elicit views on the proposed options for their further development. Experts also explained the location and function of monitoring devices and the current state of the landslide from a geological and geotechnical point of view. During this meeting, the three discourses on the preferred warning system were presented and discussed. They are categorized as 'minimal/cost', 'technical expert', and 'resident-centered', corresponding to the three rationalities (individualistic, hierarchical and egalitarian) postulated by the theory of plural rationality, which served as the conceptual framework [48–53,55,58]. As shown in Table 2, the three discourses differ along multiple criteria, including: risk awareness, responsibility allocation, cost, technology, emergency planning, resident engagement, and communication of the warning. The following sections summarize the stakeholder views on warning system issues grouped by discourses (for an in-depth description see [45] in this Special Issue).

Table 2. Warning system options.

Criteria	Minimal Cost Warning System (Individualistic)	Technical Expert Warning System (Hierarchical)	Resident Centered Warning System (Egalitarian)
Risk awareness	Landslide is not the main concern	Possibility of dynamics in upper area coming through to lower	Relevance of residual risk
Responsibility allocation	Primarily municipality	Specialized public institutions	Municipality and residents
Cost	As low as possible	Necessary costs to monitor the slope	Necessary costs to monitor the slope
Funding	Community	Municipality, region, country	Municipality, state
Technology	No new technology	Key requirement	Examine existing measures and movement of the slope manually
Emergency planning	Not necessary	Key requirement	Important aspect
Residents engagement	Minor role	Minor active role but with financial responsibility	Active role
Communication and transparency	Keep low	Information events	Information events Awareness raising and data sharing

5.1. Minimal Cost Warning System (Individualistic Discourse)

According to the minimal-cost discourse, the maintenance of existing remediation measures, which were very costly and paid for with tax money, is more important than implementing a warning system. "*What has been made works, but it needs to be maintained.*" (Geologist, A13). This discourse is rooted in the individualistic worldview insofar as it fosters what might be viewed as a rational use of public resources that balances costs and benefits. This means that maintenance of the

slope, along with other municipal projects, would have priority if they exhibited a higher benefit-cost ratio. Landslides are very slow processes that can be effectively monitored using low cost techniques, such as regular site inspections. Expensive new measuring technology using automatic data transfer and a new emergency plan are, in this discourse, not necessary to manage landslide risk in Gmunden: "*Based on my expertise, I am convinced that the slope is harmless and there is no emergency plan necessary*." (Geologist at provincial government, A14). This view is due to the perceived low risk and the existing deep knowledge of the subsurface processes. If a failure "*is not recognized, reliance on an automated system can even have worse effects than manual monitoring*" (WLV, A7). In this way a representative of the WLV describes the risk of a warning system in general. Furthermore, the implementation of a complex monitoring system and emergency plan would unnecessarily intimidate residents, lead to a loss of property values, and potentially harm tourism in the region. "*I wish that [in case of an emergency] someone tells me very quietly, so that I can quickly sell my land*" (resident, A6). Therefore, risk communication could be even disadvantageous. The relevance of new technologies and social media for risk management, according to this narrative, is negligible.

5.2. Technical Expert Warning System (Hierarchical Discourse)

To ensure safety for local residents, a technical monitoring and a warning system are required, according to this view, which is hierarchical insofar as it is rooted in trust of expertise and centralized control, legitimized with an absolute need for safety with little concern for costs. Those adhering to this narrative thus argue that, in addition to existing landslide mitigation measures, an emergency plan and fully automatic measuring tools should be installed. The emergency plan would prescribe the distribution of responsibilities, the procedure and communication/decision chains in case of emergency, and, furthermore, contact details of relevant actors. "*The warning system should be conceptualized as a multi-level expert system with defined thresholds*." (WLV, A2). An automatic alert at the Provincial Hazard Warning Center would inform the Torrent and Avalanche Control, civil engineering offices, and municipal authorities when the threshold had been exceeded. Afterwards the experts discuss and assess the situation on site and decide on next steps according to the emergency plan. The municipality, province, and state provide funding for the system, because they are responsible for the protection of citizens. Residents would not be involved in the monitoring measures, because "*you cannot rely on laypersons in observing parameters and sensors*" (WLV, A2). As a resident "*you cannot do anything, you know nothing about that*." (resident, A12). The residents, according to this narrative, will not be warned at a very early stage of an impending landslide but will be informed about the threat and next steps at a later stage when the possibility of false alarm can be ruled out. Channels of communication with those affected are mainly information events. New technologies and social media are considered to be risky for communication due to limited accessibility, data protection, and lack of control on information dissemination. The communication of wrong or misleading messages online is considered a major threat to the development of effective warning systems. "*I am very skeptical when it comes to the publication of data on webservers. It is not a no-go but it needs to be well considered how you present it. Nobody wants to see red color on such a figure, unless it means evacuation*." (WLV, A7).

5.3. Resident-Centered Warning System (Egalitarian Discourse)

According to the resident-centered discourse, an integrated or holistic multi-risk view should be adopted for designing warning systems, and residents should have a strong voice in the design and operation of the system. This discourse has strong roots in the egalitarian worldview, which is characterized by advocacy for holistic, system-changing operations and control from below. Future monitoring systems should be more inclusive, for instance by including debris flows and rock falls as additional threats to the settlement area. Inclinometers, which are technical measuring tools that provide information on the slope and landslides, along with other measures, would improve the understanding of the system and increase lead time. Responsibilities and duties in case of emergency should be clearly delineated in the emergency plan. "*If you start discussing who is responsible for what after the landslide has occurred, it doesn't work*" (civil engineer, A8). Despite the

implementation of remediation measures, there will always be a residual risk of landslides, and it is a priority to increase residents' awareness and preparedness. Proponents of this discourse also recognized the benefits of hierarchical structures, and acknowledged the advantages of having one responsible person for the system who has the professional expertise to coordinate communication and measures at the municipal level: "*Ideally, there is a responsible person close by to check if everything works. For example, if there's no power the person gets a notification, goes there and fixes it*" (Geological Survey Austria, A3).

This discourse advocated informed control from the bottom. Collected data should be accessible to all experts, authorities, and residents through internet platforms. "*If there would be public information about the current state from time to time, this would not be bad. It would be good for us all to know what's going on*" (resident, A5). Information transparency and data sharing are key to developing an effective warning system, and social media and new technology can play a vital role for risk management.

Most fundamentally, this discourse emphasizes the importance of residents being involved in the design and implementation of the system, especially since they often have a very good understanding of the mountain and its risks. Local residents thus have a vital role to play for a properly functioning risk management and warning system: locals should be included in the development, implementation, and maintenance of the warning system as well as emergency plans, and they should feel responsible for it and experience it as part of their daily lives. "*They need to feel the responsibility and see that there is something. […] 'Not anyone from Vienna is responsible, it is ours; it belongs to us, it makes us safe.' You have to take care of it and when something breaks or if there is a crack, then you have to report it*" (Geological Survey Austria, A3).

6. The Participatory Process

6.1. Workshop 1-Technology Mix

The three discourses and their respective options for the warning system, each derived from stakeholder interviews, were presented at the first stakeholder workshop in Gmunden along with recent geological findings and a geotechnical overview. The participants were divided between the resident-centered option, supported mainly by the municipality and the police, and the technical option, supported mainly by residents, especially as it related to the automated technology mix. The minimal-cost discourse and corresponding option were voiced in the interviews but not selected by any of the workshop participants. Lowering costs was primarily argued by regional authorities who were not involved in the participatory process. The technical mix of the technical option included a combination of automated precipitation and discharge measurements, inclinometer chains, and piezometers, as well as laserscan surveying and inspections on demand. This mix of monitoring technology is a slimmed-down version of an older proposal dating back to 2012, which included additional measuring devices to deliver data necessary for scientific purposes.

Before the workshop, the Torrent and Avalanche Control, the civil engineer, and the municipality had reached a compromise between the old and new version. Other stakeholders appeared to have trust in this expert proposal, or did not have any objection (see Section 6). During the workshop, the functions, requirements, and location of the devices were explained. A critical question that could not be fully resolved at this early stage concerned the risk threshold that would trigger an automated communication to experts, and whether the system should notify residents as well. While the discussion revealed a high trust in experts on the technological issues/questions, a conflict arose on the other issues. The municipality was convinced that residents should contribute to the warning system, with reference to both system and financial responsibility, while many residents were opposed. Paradoxically, the majority of residents preferred the "technical expert option" with responsibility at the municipal/expert scale, while the municipality favored the resident-centered option. The main open questions to be debated at subsequent workshops were: Who should receive the information generated by monitoring and what is the role of experts (this issue was deliberated at the second workshop)? Which responsibilities could potentially be shared,

and based on what legal basis, among residents and other stakeholders (the legal issue was deliberated at the third workshop)?

6.2. Workshop 2-Disseminating Warning Information

The second workshop focused on the interface between monitoring and communicating the warning, in conjunction with information responsibility. Based on a combination of administrative and technical components of the two most popular options from the first workshop (resident-centered and technical), the understanding was further deepened at a roundtable discussion. The aim of this workshop was convergence of participant views towards a compromise solution. The discussion was focused specifically on the topic of information responsibility for disseminating warning messages or sounding the alarm. Two key issues emerged: the first concerned the monitoring threshold at which an alarm should be disseminated or sounded; the second related to regular information and awareness raising. Participants argued for transparency, meaning that they would like to be informed early about the danger, but not every time the monitoring devices detect a system change. Most participants supported that experts should be the target of the automated warnings from the monitoring system: "*One should not worry people for every small reason*." (resident, A18). Residents argued that they do not want to be annoyed by false alarms and that experts are responsible for warning management. Indeed, the collateral effects of false alarms can hamper the effectiveness of the warning system during an emergency. These effects include reduced reaction by people who have experienced false alarms and economic loss due from tourism. The outcome of this discussion was clear in terms of a warning being targeted only to experts in the first stage, assuring that warnings go out at appropriate times, possibly managed through the warning center at the provincial level. In case the measurements show a high landslide risk, experts alarm the municipality and form a committee that either includes a delegate from residents or informs residents accordingly. The trust in experts increased as a result of their explanations and clarifications throughout the process. Automation as a basic principle for the system in Gmunden was accepted by participants. This means that most of them trusted in the sensor technology described above to monitor the landslide and ensure an efficient warning. A resident emphasized: "*People come and go*!" (workshop discussion, A18) and there must be a system that is independent of single persons. Again, among the participants, the residents leaned towards the hierarchical option, which means that they rely on authorities in taking information responsibility for the warning despite their general, but decreasing, distrust in them.

The second key issue relates to regular information and awareness raising. All participants agreed on the need for annual events that provide information on the landslide risk status, the state of the danger zone, and the warning system. In order to inform the wider public, a so-called "geotrail" (information boards along roads containing general information about the landslide and the measures taken) could be installed in the area, which would raise awareness about the geology and the scientific relevance of the risk zone. While designing public information channels, it was important to create understanding that awareness raising does not necessarily mean panic-mongering. For example, some residents feared that awareness raising about the landslide risk could harm tourism and property values. This anxiety shows a conflict between touristic/economic development and the promotion of safety at the local level, a quite common problem often hindering effective risk management [59]. In contrast to an expert-led warning communication, the responsibility for regular information could be shared between residents and local authorities and experts. Potential operationalization of information responsibility sharing was discussed at the third workshop, linked with system and financial responsibility.

6.3. Workshop 3-Responsibility and Compromise Solution

As described above, a main question that remained open after the first workshop was the allocation of financial, system, and information responsibilities among the stakeholders, and the legal basis for this allocation. The aim of the third workshop was to discuss the legal possibilities for enhanced resident involvement in the long-term funding, operation, and maintenance of the

warning system. A guest speaker with legal expertise informed participants about the legal possibilities of a resident association and experts provided their opinion about responsibility devolvement. This workshop revealed a contestation about responsibility sharing and the paradoxical views on whether responsibility for monitoring presides with the authorities or the residents.

In contrast to the agreement on technology and the design of information provision, the aspect of responsibility allocation and the degree of resident involvement in the long-term maintenance of the system were especially contested. The legal expert presented two scenarios, respectively focused on shared and public responsibility. Table 3 provides an overview of the key characteristics of each of the two scenarios.

Table 3. Overview of the organizational options.

Distinguishing Feature	Shared Responsibility-Resident Association	Public Responsibility-Municipality
Role of residents	Cost contribution (approx. EUR 400/year; varies according to land size); participate at drills and information events; chair of resident association: coordination of maintenance, decision making, communication, organize drills, and information events	Cost contribution (approx. EUR 400/year; varies according to land size), participate at drills and information events; report observations
Role of municipality	Cost contribution (for road and infrastructure link); emergency management	Cover cost that exceeds contributions; coordination of maintenance, decision making, communication, drills, and information events; emergency management
Role of experts	Warning interpretation; data management; maintenance	Warning interpretation; data management; maintenance
Role of relief forces	Support maintenance and emergency	Support emergency
Who is responsible?	Resident association and experts for monitoring, mayor for emergency management	Mayor and experts
Who is the end-user?	Residents	Municipality
Who is the monitoring committee?	Provincial Warning Center, WLV, civil engineer, (Geological Survey Austria, University of Natural Resources and Life Sciences Vienna), chair of association	LWZ, WLV, civil engineer, (GSA, BOKU)
Who is the action committee?	Mayor, WLV, civil engineer, chair of association, police, fire brigade	Mayor, WLV, civil engineer, police, fire brigade
Who benefits how?	Municipality less responsible, residents can co-determine, better chances for subsidies, more awareness and appreciation, better legitimacy among the general public	Less complex decision making for municipality, established structure as a benefit for all, residents less responsible

Experts explained the advantages and disadvantages of resident associations and how different versions distributed responsibility away from public authorities. They pointed out that an association provides residents with designated rights of control over the system and timely information about the risks. These advantages do not depend on who pays for the system, since, in principle, the municipality can charge residents for the system in either option (this is actually a current political discussion which has not yet been decided by the municipality).

More precisely, the residents' association would ground the warning system in a legal construct called a Water Management Association according to WRG 1959 in Austria. Commonly used for decentralized waste-water or water-supply projects, experts suggested its suitability for landslide risk mitigation. The advantage is that the association presents the possibility for a majority to outvote a minority for the sake of the functioning of the association's purpose, which must be agreed

on during the founding procedures. The multi-risk emergency plan, which the municipality was preparing at the time of this research, could contain a landslide component that is maintained by the association. Another potential purpose is the integration with a planned forest project by the Austrian Federal Forestry and the Torrent and Avalanche Control. However, this would pertain to a larger area than the landslide danger zone.

Paradoxically, mainly residents were skeptical about the formation of a resident association, which, however, was favored by experts and public authorities. The residents preferred to keep system responsibilities at the municipal level to save them the effort of founding an association, while local authorities favored shared responsibility [44]. The residents also argued (falsely) that the municipality's issuance of permits for residents to buy property and build homes obligated the public to ensure its safety. Although the land-use law cannot be reversed for the already existing property, there is no legal obligation to ensure its safety by the state or municipality. About half of the residents present at the workshop appeared to accept a move towards shared responsibility of operational decisions and contribution to running costs by residents, but the other half argued against any shared financial, system, or information responsibility in the maintenance of the warning system. Misunderstandings were resolved during the workshop, especially the concern by residents that the yearly fees for maintaining the systems would be high and that residents would replace experts in directly maintaining the monitoring technology. Thus, some residents were prepared to assume some financial responsibility but were reluctant to accept system responsibility.

A major concern that remained among all residents was the uncertainty that the design and operational conditions of the warning system would change from what was agreed at the workshop. For example, some feared that the resident fees would eventually be raised above the amount discussed. Residents were generally concerned about the long-term functioning of the warning system. Experience with short-term politics and research contracts raised skepticism about the sustainability of any policy engagement. Indeed, the perception of institutional risk seemed to be higher than the landslide risk. Partly as a consequence of this skepticism towards public authorities, residents were disinterested in subsidies from the federal and provincial level that rewarded resident contribution as an incentive for public participation.

In conclusion, during the workshops there was a clear shift towards a compromise solution. The outcome of the workshops suggests the following design of the warning system in Gmunden (see Figure 2). The warning would be fully automated, using inclinometers, piezometers, and measurements of precipitation and discharge, as well as laserscan monitoring and inspections on demand. The collected data would be administered by geotechnical experts who would assure that warnings went out at appropriate times, while awareness should be raised through regular information events among local stakeholders and information boards for the general public. The monitoring committee (experts and end-user representatives) would work closely with the emergency committee, which would be conventionally organized through the mayor, relief forces, and the Torrent and Avalanche Control. Responsibility to coordinate and finance maintenance would be kept at the municipality, with the possibility to charge residents for running costs. A resident spokesman should be invited to municipal and expert consultations. The formal responsibility lies at the mayor's office, but the consultants and residents play an important role. The advantage is that this would save the cost of an association while ensuring a strong voice on the part of the residents; however, the residents would have no legal right to co-determine in the design and operation of the system.

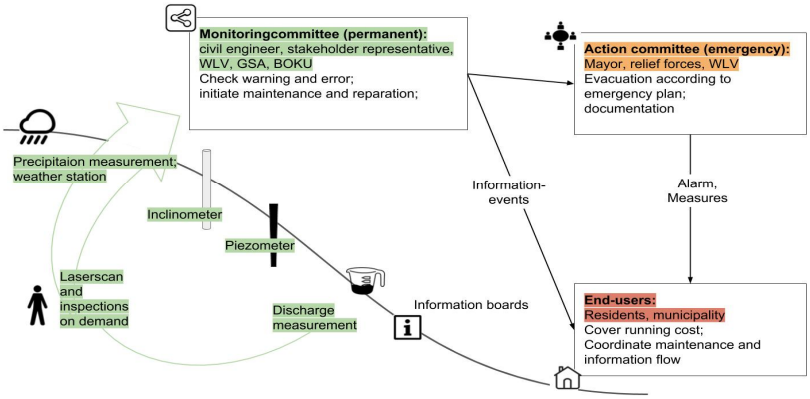

Figure 2. Conceptual overview of compromise solution.

7. Discussion

Building on previous research [1,13,52], the Austrian case study demonstrates the opportunities and challenges of public participation in landslide risk mitigation and, specifically, a warning system, and the usefulness of eliciting stakeholder worldviews, interests, and conflicts. We examined how financial, system, and information responsibilities can be shared during the design and operation of warning systems. We observed in the case of Gmunden how stakeholder groups agree and disagree on shared financial, system, and information responsibilities and how the participants in a deliberative process debate the institutional and legal consequences of the design and operation of a landslide warning system. Based on interviews and a desk study, three options were developed that bundled the technological, social, economic, and legal preferences of stakeholders. The options fed into a series of stakeholder workshops, which ultimately reached a compromise on the technology mix, the information policy, and theespecially contested question of responsibility sharing. Stakeholders had divergent views about responsibility during the operation of the warning system and the forms of citizen-state relationships that best enabled it. This led to a conflict between public and private responsibility. We conclude with a discussion of motives and reasons for this disagreement including (personal) conflicts among stakeholders, (financial) interests, and differing world views.

Residents were skeptical as to whether the efforts to mitigate landslide risk were long-term due to the short-term logic of politics and public administration. Despite this skepticism, and partly because of their interest in benefiting from public services, resident participants in the process concluded that the municipality and its experts should administer the warning system, manage the monitoring of information, and sound the alarm. Many residents then chose the hierarchical option of a strongly technological system, controlled by the authorities and their experts. Paradoxically, then, residents rejected a resident association that would ensure them control and expanded rights for information. At the same time, assuming responsibility—especially system responsibility—requires cooperation at the neighborhood level; personal conflicts between residents and a very heterogeneous community impeded this egalitarian solution. From the standpoint of the public authorities, we found a similar paradoxical situation where world views appeared to be dominated by interests. The municipality took the opposite view, preferring participation and co-production in the landslide warning system, which derived from their interest in devolving financial, system, and information responsibilities.

The municipality's position was also fueled by previous contestations about differing views and informal relations between consultants and residents. Many stakeholders took advantage of this history to elicit the main directions towards a compromise solution. The outcome of the compromise was a moderated mix of technologies, an expert-dominated information policy, municipal

responsibility for the administration of the warning system, and a moderate contribution to the costs by residents.

The stakeholder process in Gmunden showed that public participation can be successful in reaching an accepted solution to contested issues of managing landslide risk. While considering conflicts and interests, world views proved useful in framing stakeholder perspectives in finding a compromise solution. Although many issues remain unresolved, particularly the legal basis for shared responsibility, the study contributes to resolving issues in landslide risk mitigation, and particularly shared responsibility for a warning system, through a participatory process. The case study in Austria will be relevant in many countries interested in participatory processes for managing the risk of landslides and other natural hazards.

Acknowledgments: The work described in this publication was supported by the Austrian Academy of Sciences' international research initiative "Earth System Science" (ESS) through the grant to the budget of the LAMOND Project. The paper reflects the authors' views and not those of the Austrian Academy of Sciences. Any member of the LAMOND Consortium is liable for any use of the information in this paper. We thank the stakeholders in Gmunden who devoted their precious time to the interviews and workshops.

Author Contributions: All authors conceived and designed the research. Philipp Preuner, David Ottowitz, Birgit Jochum, and Stefan Hoyer conducted the fieldwork. Philipp Preuner, Anna Scolobig, and JoAnne Linnerooth-Bayer analyzed the data. Philipp Preuner with contribution of all co-authors wrote the paper.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Linnerooth-Bayer, J.; Scolobig, A.; Ferlisi, S.; Cascini, L.; Thompson, M. Expert engagement in participatory processes: Translating stakeholder discourses into policy options. *Nat. Hazard.* **2016**, *81*, 69–88.
2. Scolobig, A.; Prior, T.; Schröter, D.; Jörin, J.; Patt, A. Towards people-centred approaches for effective disaster risk management: Balancing rhetoric with reality. *Int. J. Disaster Risk Reduct.* **2015**, *12*, 202–212.
3. Kuhlicke, C.; Steinführer, A.; Begg, C.; Bianchizza, C.; Bründl, M.; Buchecker, M.; De Marchi, B.; Di Masso Tarditti, M.; Höppner, C.; et al. Perspectives on social capacity building for natural hazards: Outlining an emerging field of research and practice in Europe. *Environ. Sci. Policy* **2011**, *14*, 804–814.
4. Challies, E.; Newig, J.; Thaler, T.; Kochskämper, E.; Levin-Keitel, M. Participatory and collaborative governance for sustainable flood risk management: An emerging research agenda. *Environ. Sci. Policy* **2016**, *55*, 275–280.
5. Kelman, I. Climate change and the Sendai framework for disaster risk reduction. *Int. J. Disaster Risk Sci.* **2015**, *6*, 117–127.
6. Ryfe, D.M. Does deliberative democracy work? *Annu. Rev. Politics Sci.* **2005**, *8*, 49–71.
7. Rosenberg, W.S. Rethinking democratic deliberation: The limits and potential of citizen participation. *Polity* **2007**, *39*, 335–360.
8. Pellizzoni, L. Une idée sur le déclin? Evaluer la nouvelle critique de la délibération publique. *Participations* **2013**, *2*, 87–118.
9. Few, R.; Brown, K.; Tompkins, E.L. Public participation and climate change adaptation: Avoiding the illusion of inclusion. *Clim. Policy* **2007**, *7*, 46–59.
10. Mielke, J.; Vermaßen, H.; Ellenbeck, S.; Fernandez Milan, B.; Jaeger, C. Stakeholder involvement in sustainability science—A critical view. *Energy Res. Soc. Sci.* **2016**, *17*, 71–81.
11. Thaler, T.; Levin-Keitel, M. Multi-level stakeholder engagement in flood risk management—A question of roles and power: Lessons from england. *Environ. Sci. Policy* **2016**, *55*, 292–301.
12. Scolobig, A.; Lilliestam, J. Comparing approaches for the integration of stakeholder perspectives in environmental decision making. *Resources* **2016**, *5*, 37.
13. Scolobig, A.; Thompson, M.; Linnerooth-Bayer, J. Compromise not consensus: Designing a participatory process for landslide risk mitigation. *Nat. Hazard.* **2016**, *81*, 45–68.
14. Parker, D.; Fordham, M. An evaluation of flood forecasting, warning and response systems in the European Union. *Water Resour. Manag.* **1996**, *10*, 279–302.
15. Parker, D. Criteria for evaluating the condition of a tropical cyclone warning system. *Disasters* **1999**, *23*, 193–216.

16. Sharma, U.; Patt, A. Disaster warning response: The effects of different types of personal experience. *Nat. Hazard.* **2012**, *60*, 409–423.
17. Parker, D.J. Designing flood forecasting, warning and response systems from a societal perspective. *Meteorol. Z.* **2004**, *13*, 5–11.
18. United Nations International Strategy for Disaster Reduction. *Global Survey of Warning Systems; An Assessment of Capacities, Gaps and Opportunities Towards Building a Comprehensive Global Early Warning System for all Natural Hazards*; UNISDR: Geneva, Switzerland, 2012.
19. Morss, R.E.; Mulder, K.J.; Lazo, J.K.; Demuth, J.L. How do people perceive, understand, and anticipate responding to flash flood risks and warnings? Results from a public survey in Boulder, Colorado, USA. *J. Hydrol.* **2016**, *541*, 649–664.
20. Morss, R.E.; Demuth, J.L.; Bostrom, A.; Lazo, J.K.; Lazrus, H. Flash flood risks and warning decisions: A mental models study of forecasters, public officials, and media broadcasters in Boulder, Colorado. *Risk Anal.* **2015**, *35*, 2009–2028.
21. Sättele, M.; Bründl, M.; Straub, D. Quantifying the effectiveness of early warning systems for natural hazards. *Nat. Hazard. Earth Syst. Sci.* **2016**, *16*, 149–166.
22. Mees, H.; CrabbÈ, A.; Alexander, M.; Kaufmann, M.; Bruzzone, S.; LÈvy, L.; Lewandowski, J. Coproducing flood risk management through citizen involvement: Insights from cross-country comparison in Europe. *Ecol. Soc.* **2016**, *21*, 3.
23. United Nations International Strategy for Disaster Reduction. *Hyogo Framework for Action 2005–2015: Building the Resilience of Nations and Communities to Disasters*; UNISDR: Geneva, Switzerland, 2005.
24. De Marchi, B.; Funtowicz, S.O.; Lo Cascio, S.; Munda, G. Combining participative and institutional approaches with multicriteria evaluation. An empirical study for water issues in Troina, Sicily. *Ecol. Econ.* **2000**, *34*, 267–282.
25. National Research Council. *Public Participation in Environmental Assessment and Decision Making*. National Academic Press: Washington, DC, USA, 2008.
26. De Marchi, B. Public participation and risk governance. *Sci. Public Policy* **2003**, *30*, 171–176.
27. Prior, T.; Paton, D. *Understanding the Context: The Value of Community Engagement in Bushfire Risk Communication and Education. Observations Following the East Coast Tasmania Bushfires of December 2006*; Massey University: Wellington, New Zealand, 1996; Volume 28, pp. 1–14.
28. Pelling, M. Learning from others: The scope and challenges for participatory disaster risk assessment. *Disasters* **2007**, *31*, 373–385.
29. Newig, J.; Kochskämper, E.; Challies, E.; Jager, N.W. Exploring governance learning: How policymakers draw on evidence, experience and intuition in designing participatory flood risk planning. *Environ. Sci. Policy* **2016**, *55*, 353–360.
30. Patterson, O.; Weil, F.; Patel, K. The role of community in disaster response: Conceptual models. *Popul. Res. Policy Rev.* **2010**, *29*, 127–141.
31. Renn, O. *Risk Governance. Coping with Uncertainty in a Complex World*; Earthscan: London, UK, 2008.
32. Fischhoff, B. *The Sciences of Science Communication*. National Academy of Sciences: Washington, DC, USA, 2012; pp. 14033–14039.
33. Ulusoy, K. The foundations of deliberative democracy. *METU Stud. Dev.* **2012**, *39*, 247–351.
34. Scolobig, A. Brief communication: The dark side of risk and crisis communication: Legal conflicts and responsibility allocation. *Nat. Hazard. Earth Syst. Sci.* **2015**, *15*, 1449–1456.
35. Stucchi, M.; Pinho, R.; Cocco, M. After the L'Aquila Trial. *Seismol. Res. Lett.* **2016**, *87*.
36. Bretton, R.J.; Gottsmann, J.; Aspinall, W.P.; Christie, R. Implications of legal scrutiny processes (including the l'aquila trial and other recent court cases) for future volcanic risk governance. *J. Appl. Volcanol.* **2015**, *4*, 18.
37. Lauta, K.C. *Disaster Law*; Routledge: New York, NY, USA, 2014.
38. Scolobig, A.; Mechler, R.; Komendantova, N.; Wei, L.; Schröter, D.; Patt, A. The co-production of scientific advice and decision making under uncertainty: Lessons from the 2009 Lâ€™ earthquake, Italy. *Planet@Risk* **2014**, *2*, 71–76.
39. Gasperl, W. Katastrophenbewältigung und maßnahmen im Gschliefgraben (Gmunden/Oberoesterreich). In *Öaw-Gschliefgraben-Symposium 2009-Proceedings,* Weidinger, J.T., Köck, G., Eds.; Verlag der Österreichischen Akademie der Wissenschaften: Wien, Austria, 2010; pp. 45–58.

40. Forsttechnischer Dienst der Wildbach- und Lawinenverbauung. *Großhangbewegung Gschliefgraben–Fachübergreifender Synthesebericht*; Wildbach- und Lawinenverbauung (WLV): Wien, Austria, 2009.
41. Gamper, C.D. The political economy of public participation in natural hazard decisions—A theoretical review and an exemplary case of the decision framework of Austrian hazard zone mapping. *Nat. Hazard. Earth Syst. Sci.* **2008**, *8*, 233–241.
42. Forsttechnischer Dienst der Wildbach- und Lawinenverbauung. *Gschliefgraben Monitoring und Frühwarnung; Technischer Bericht*; Wildbach- und Lawinenverbauung (WLV): Wien, Austria, 2012.
43. Weidinger, J.T. Das Gschliefgraben-rutschgebiet am Traunsee-ostufer (Gmunden/OOE)-ein jahrtausende altes Spannungsfeld zwischen Mensch und Natur; *Jb. Geol. B.-A.* **2009**, *149*, 195–206.
44. Damm, A.; Eberhard, K.; Sendzimir, J.; Patt, A. Perception of landslides risk and responsibility: A case study in Eastern Styria, Austria. *Nat. Hazard.* **2013**, *69*, 165–183.
45. Scolobig, A.; Riegler, M.; Preuner, P.; Linnerooth-Bayer, J.; Ottowitz, D.; Hoyer, S.; Jochum, B. Warning system options for landslide risk: A case study in upper Austria. *Resources* **2017**, *6*, 37.
46. Silverman, D. *Doing Qualitative Research*, 4th ed.; SAGE Publications Ltd.: London, UK, 2013.
47. Dryzek, J. *Environmental Discourses*; Oxford University Press: New York, NY, USA, 1997.
48. Thompson, M.; Rayner, S. Risk and governance part 1: The discourses of climate change. *Gov. Oppos.* **1998**, *33*, 139–166.
49. Thompson, M.; Ellis, R.; Wildavsky, A. *Cultural Theory*; Westview Press: Boulder, CO, USA, 1990.
50. Ney, S.; Thompson, M. Cultural Discourses in the Global Climate Change Debate. In *Society, Behaviour and Climate Change Mitigation*; Eberhard, J., Sathaye, J., Bouille, S., Eds.; Kluwer Academic Publishers: Dordrecht, The Netherlands, 1999.
51. Verweij, M.; Thompson, M. *Clumsy Solutions for a Complex World: Governance, Politics, and Plural Perceptions*; Palgrave Macmillan: New York, NY, USA, 2006.
52. Thompson, M. *Organizing and Disorganizing: A Dynamic and Non-Linear Theory of Institutional Emergence and Its Implications*; Triarchy Press: London, UK, 2008.
53. Yazdanpanah, M.; Hayati, D.; Thompson, M.; Yamani, G.; Monfarad, N. Policy and plural responsiveness: Taking constructive account of the ways in which Iranian farmers think about and behave in relation to water. *Hydrology* **2014**, *514*, 347–357.
54. Gyawali, D.; Thompson, M.; Verweij, M. *Aid, Technology and Development: The Lessons from Nepal*; Eathscan Routledge: London, UK, 2017.
55. Singleton, B. Clumsiness and elegance in environmental management: Applying cultural theory to the history of whaling. *Environ. Politics* **2016**, *25*, 414–422.
56. Cash, D.W.; Clark, W.C.; Alcock, F.; Dickson, N.M.; Eckley, N.; Guston, D.H.; Jäger, J.; Mitchell, R.B. Knowledge systems for sustainable development. *Proc. Natl. Acad. Sci.* USA **2003**, *100*, 8086–8091.
57. Löschner, L.; Nordbeck, R.; Scherhaufer, P.; Seher, W. Scientist–stakeholder workshops: A collaborative approach for integrating science and decision-making in Austrian flood-prone municipalities. *Environ. Sci. Policy* **2016**, *55*, 345–352.
58. Thompson, M. Wicked environmental problems. In *The Companion to Environmental Studies*; Hulme, M., Ed.; Cambridge University Press: Cambridge, UK, 2017.
59. De Marchi, B.; Scolobig, A. The views of experts and residents on social vulnerability to flash floods in an alpine region of Italy. *Disasters* **2012**, *36*, 316–337.