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Ecosystem Perceptions in Flood Prone Areas: A Typology and Its Relationship to Preferences for Governance

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Abstract: A shift appears to be occurring in thinking about flooding, from a resistance-based approach to one of resilience. Accordingly, how stakeholders in flood-prone regions perceive the system and its governance are salient questions. This study queried stakeholders' internal representations of ecosystems (resistance- or resilience-based), preferences for governance actors and mechanisms for flooding, and the relationship between them in five different regions of the world. The influence of personal experience on these variables was also assessed. Most respondents aligned themselves with a resilience-based approach in relation to system connectedness and response to disturbance; however, respondents were almost evenly split between resistance- and resilience-based approaches when considering system management. Responses generally were considered to hold for other disturbances as well. There was no clear relationship between internal representations and preferences for governance actors or mechanisms. Respondents generally favoured actor combinations that included governments and mechanism combinations that included regulations and policies. Those who had personal experience with flooding tended to align themselves with a resilience-based internal representation of system management, but personal experience showed no clear relationship with governance preferences. The findings support an evolutionary perspective of flood management where emerging paradigms enhance preceding ones, and prompt a critical discussion about the universality of resilience as a framing construct.

Keywords: ecosystem perception; flooding; governance; resilience

1. Introduction

Flooding has major impacts globally, and the risk of flooding is expected to increase substantially over time. Although a rough estimate, the first projection of global flood risk using climate models suggested that 20–300 million people are affected by flooding annually, with the upper bound becoming the number of people confronting risk during a year of low flooding by 2060 and several times that

number facing risk in a bad flooding year [1]. Contemporary and future losses in the largest 136 coastal cities worldwide from floods alone reveals average annual losses of 6 billion (USD) in 2005 and are projected to rise to $52 billion (USD) by 2050 [2]. Jongman *et al.* [3] provide an initial estimation of economic exposure globally from coastal and river flooding to be 46 trillion (USD) in 2010 and 158 trillion (USD) in 2050 using population projection methods and 27 trillion (USD) in 2010 and 80 trillion (USD) in 2050 using land use methods. It is generally expected that flood risk globally will intensify over time due to population increases and their locations, the vulnerability of human assets and systems, and impacts from climatic and environmental changes (e.g., Jongman *et al.* [3]; Intergovernmental Panel on Climate Change (IPCC) [4]; Kron [5]).

A significant shift appears to be underway in contemporary thinking about floods. Schanze [6] documents the evolution of approaches to mitigating flood impacts by humans into three paradigms, noting that each enhances the preceding one(s). The first paradigm of "flood protection" entailed observing patterns of flooding, altering waterways, and changing land uses. While initially done on a small scale, the paradigm's influential legacy persists and is the foundation for present major flood defense structures. The realization that absolute protection from floods is unreasonable has led to the second paradigm of "risk management", in which the flood system is more comprehensively viewed (nature of the flood hazard, exposure, vulnerability) to manage risk at a tolerable level. "Resilience" may be a candidate for the third paradigm, and in it, special relevance for risk management and governance regimes come from: considering resilience in an expanded meaning of vulnerability; learning from prior events; and enhanced response capacities [6].

Others characterize the change in flood risk management as a transition from a resistance-based approach, which focuses on robustness, to a resilience-based approach, which accepts risks and stresses adaptation [7–11]. Temples and Hartman [10] (p. 873) usefully differentiate the approaches: "the first usually requires modelling and prediction, technical flood protection measures such as dikes, and strong water management institutions with technical skills. The latter depends on comprehensive and integrative concepts, encompassing many stakeholders and asking for collaboration at various levels". In addition to the obvious operational aspects of flood management, these approaches confer the need to consider societal steering or governance.

Flood, and flood risk governance can be considered as a specific case of disaster governance which " . . . consists of the interrelated sets of norms, organizational and institutional actors, and practices (spanning predisaster, transdisaster, and postdisaster periods) that are designed to reduce the impacts and losses associated with disasters arising from natural and technological agents and from intentional acts of terrorism" [12] (p. 344). Issues of governance in relation to flooding are gaining traction by scholars. The inclusion of multiple actors who each bring their own perceptions, of risk (as opposed to flood prevention approaches) [13], as well as the specific involvement of public and private actors in adaptive flood risk governance [9] are examples of these issues. Analyses of flood risk governance arrangements are an emerging and nascent area of study [14]. Plummer *et al.* [15] contribute to filling this void with their international multiple case study of flood governance. Their examination of flood governance (pre-event, during the occurrence, post-event) revealed little consensus by stakeholders about current practices and a high desirability that it should ideally take place at multiple levels, involve diverse actors, and occur via multiple mechanisms.

Foundational to the transition in contemporary thinking about flooding, and complex resource systems more broadly, is people's perceptions of how nature operates. Psychology and cognitive sciences have long been concerned with how individuals internally represent the external world and the implications of those depictions, with Craik [16] and Johnson-Laird [17] introducing and developing the concept of 'mental models'. Mental models, dynamic cognitive representations individuals construct and draw upon to guide external interactions, are now employed across disciplines and are gaining attention in natural resources management (see Jones *et al.* [18] for a summary). While experience and disciplinary theories are responsible for some complex resource system failures, Holling *et al.* [19] trace others to more deep-seated limitations—differences among

worldviews. Similar to mental models, the caricatures of nature they present are representations (aspects of reality) that permit provisional certitude for policies and actions. Comparable connections have been made in specific regards to natural hazards where human perception and understanding are essential to vulnerability [4] and psychological mechanisms and mental models are identified as more accurate depictions of risk perceptions compared to human senses [20]. While there are several influences that affect thinking about flooding (e.g., economic realities, institutional constraints, and pragmatic approaches [21], unfortunately " ... the underlying worldview is seldom put on the table when actions for the future are discussed, but it will strongly influence the direction and potential for a sustainable future" [22] (p. 2028).

This foundational connection with specific reference to floods is emerging in the literature. For example, floods have traditionally been framed solely in terms of the water system and natural-physical disturbances (*i.e.*, an engineering resilience perspective), but a co-evolutionary perspective is emerging which draws attention to the interactions between physical and social systems [10]. Liao [8] (online) identifies that resilience in this context usually emphasizes the return to pre-disaster state, but argues that "applying the engineering resilience concept to communities that are subject to natural hazards is fundamentally problematic because of the outdated equilibrium paradigm". The shift in thinking about floods is reflective of the more general 'rise of a new water paradigm' in relation to the Anthropocene, in which systems are conceptualized as interconnected (social-ecological), complex and adaptive [23].

Against this conceptual backdrop, views held by individuals about ecosystems (in the broadest sense) and their management in reference to flooding are empirically investigated in this study. The influences of these underlying perspectives are then examined in relation to growing interest in issues of governance—who should be responsible for making decisions in the context of flood risk and response, and what mechanism(s) are best suited to implementing societal interventions. Questions about internal representations of the system and flood governance were explored through a multiple case study approach in five flood-prone regions.

2. Methods

A multiple case study approach was used in this project to assess perceptions and preferences across flood prone areas. Five cases were selected that represented developed, democratic nations with a range of flooding contexts: major urban flooding in southeast Queensland, Australia; urban and rural riverine flooding of the Red River in Manitoba, Canada; urban tidal flooding in Venice, Italy; riverine flooding of the Meuse River in the Netherlands; and, riverine and coastal flooding of Kristianstad, Sweden. For detailed information about each case, see Plummer *et al.* [15].

Researchers familiar with the cases were identified and helped facilitate access to stakeholders in their respective cases. Stakeholders were defined as individuals working within organizations, agencies or other groups with a clear interest in flooding. These included government employees, individuals working in non-governmental organizations, in industry, and as researchers in roles such as managers, technical staff, policy makers, and field workers. All stakeholders identified by case researchers (N = 816) were invited, via e-mail, to participate in an online survey (FluidSurveys, Inc.) in February 2015. Potential respondents were invited by case researchers to participate, except in Australia where the lead researchers contacted potential respondents. Two reminder e-mails were sent two weeks and three days before the closing date for the survey. The overall response rate was 32% (accounting for 42 invitations that were not deliverable), with 251 completed surveys (see Table S1 for case level response rates).

The survey instrument was developed as a result of several previous efforts. First, an extensive survey of the resilience literature and a series of guiding questions were used to evaluate differences among four internal representations (*i.e.*, mental models) of resilience: engineering [24–26]; ecological [27–29]; social-ecological [28,30,31]; and, epistemic [32,33] (see Krievins *et al.* [34] for a detailed account of each). Four criteria were initially selected that represented the key ways in which representations of the ecosystem could be distinguished in documents typifying water dilemmas via

content analysis [35]. These criteria (how the system operates, connectedness of the system, how the system responds to disturbances, how the system should be managed) were tested for their suitability in elucidating internal representations of the ecosystem using a survey instrument in the Niagara River Watershed in Canada [21]. The criteria were subsequently critically assessed and revised criteria were developed for the survey in this study. The three criteria were: connectedness of the system; how the system responds to disturbances; and, how the system should be managed (see Appendix A for the survey questions). The universality of responses was tested by asking respondents to indicate if their responses would change if considering disturbances other than flooding. Also, the influence of personal experience of flooding on internal representations was explored by asking respondents if they had experienced any damage to their personal property in the past 10 years (Figure 1).

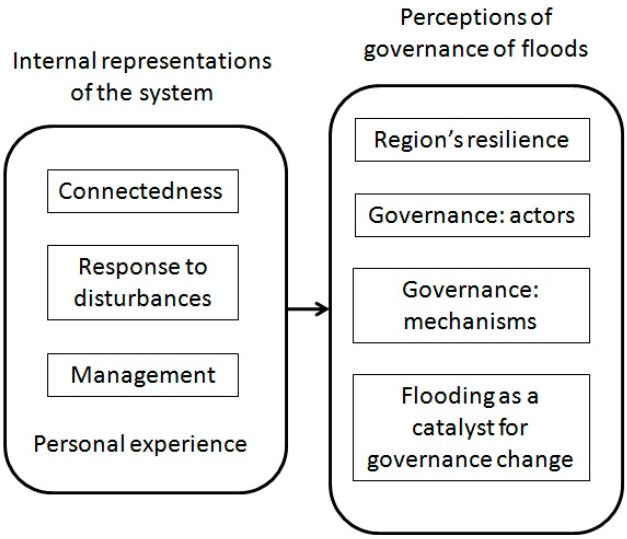

Figure 1. Framework for analysis.

Internal representations of the ecosystem were also framed in terms of "resistance-based" and "resilience-based" approaches (following Tempels and Hartman [10]). The resistance-based approach collapsed engineering and ecological resilience internal representations, where systems may be considered linear or not, but social systems are viewed separately from ecological systems. Response to disturbances results in return to a single, or one of multiple, stability domain(s). Management of the system is generally considered possible by isolating and addressing the issue or by focusing entirely on ecological problems [29,36,37]. The resilience-based approach collapsed social-ecological and epistemic resilience internal representations. These views are collectively characterized by the recognition of interconnectedness of social and ecological systems. System response to disturbances includes a strong focus on adaptation and learning, and the system boundaries and issues may be collectively defined and managed by multiple stakeholders [28,30,32].

The relationship between internal representations (and resistance-based and resilience-based approaches) and perceptions of governance of floods was investigated. Specifically, four variables related to perceptions of governance were measured: perceptions of respondents' region in terms of its resilience (structured as a binary yes/no response, with an open question follow up for reasons why); perceptions of whether or not flooding has acted as a catalyst for governance change (structured as a binary yes/no response); preferences for governance actors and preferences for governance mechanisms. Options for governance actors and mechanisms were developed from the environmental governance work of Glasbergen [38], Lemos and Agrawal [39], and Armitage *et al.* [40]. Three idealized types of governance: state-centered, civil society-based, and market-based, as well as all combinations of these idealized types, were provided to respondents as options in terms of actors and mechanisms (two separate questions). Preferences for governance actor types and mechanism types were queried

using a ranking approach: respondents were asked to place all of the options presented in order from most to least preferred. For a more detailed description of the governance types, please see Plummer *et al.* [35] and Plummer *et al.* [15].

The data were analysed using SPSS 21 package (IBM Corp; Armonk, NY, USA) and non-parametric tests were used to examine the relationships between the variables as the data was nominal or not normally distributed (*i.e.*, preference of governance). More specifically, chi-squared tests of independence were used to examine if relationships existed between resistance/resilience-based approaches as well as personal experiences and perceptions of a region's resilience to flooding and flooding as a catalyst for change in governance. Mann-Whitney U-tests were used to examine differences in preference for governance actors and mechanisms between resistance and resilience-based approaches as well as between those who had and did not have personal experiences with flooding.

There are some limitations to this research. First, respondents were able to provide multiple job roles in the survey, which precluded analyzing the responses in terms of role and respondent type. However, as indicated in the results, respondents exhibited diversity in their roles. A second limitation of the research relates to the ability to extrapolate the findings beyond the specific disturbance of flooding. While a question was posed regarding whether views would change when considering a different disturbance (see Appendix A for survey questions), we cannot ascertain what disturbances respondents may have considered when answering the question and cannot claim that the internal representations hold in all cases.

3. Results

3.1. Internal Representations of the Ecosystem

Individuals were asked their opinions on the connectedness of the system, how it responds to disturbances and how it should be managed. The original responses were distributed across four resilience types: engineering, ecological, social-engineering and epistemic (Table 1). The responses were then collapsed across the four internal representations to form resistance-based (engineering and ecological) and resilience-based (social-ecological and epistemic) groups of respondents. These groupings are used in the remainder of the results.

Table 1. Distribution of responses across the internal representations of the system.

Question	Resilience Type			
	Resistance-Based		Resilience-Based	
	Engineering	Ecological	Social-Ecological	Epistemic
Connectedness	1.2% (n[1] = 3)	2.8% (n = 7)	74.1% (n = 186)	21.9% (n = 55)
Response to disturbance	12.0% (n = 30)	22.7% (n = 57)	52.2% (n = 131)	13.1% (n = 33)
Management approach	42.2% (n = 106)	0.4% (n = 1)	10% (n = 25)	47.4% (n = 119)

[1] Number of respondents within a sub-group.

A majority of participants reported supporting the resilience-based approach across all three questions. More specifically, when asked about their view of the connectedness of the system, a majority of individuals (96%, n = 242) selected the resilience-based approach. Similarly, 65% (n = 164) of respondents chose the resilience-based approach when asked about the system's response to disturbance. Opinions on how the system should be managed were less obviously aligned with one approach such that only 57% (n = 144) chose the resilience-based approach. Responses to the questions were independent of each other, such that perceptions of the connectedness of the system did not

interact with views of how the system responds to disturbance ($p = 0.087$) or how the system should be managed ($p = 0.315$). Perceptions of a system's responses to disturbance also did not influence respondents' views on how the system should be managed ($p = 0.455$).

A majority of individuals (69%, $n = 174$) also indicated that their answers to these questions would not have changed if asked about a different disturbance (*i.e.*, other than flooding). A majority of individuals who reported that they *would* change their answers (55%, $n = 42$) selected the resistance-based approach; whereas a majority of those who *would not* change their answer (63%, $n = 109$) chose the resilience-based approach when asked about the management of the system ($p = 0.008$). There were no other significant differences in proportions of people aligned with a particular internal representation and specificity of responses to flooding (connectedness: $p = 0.367$; response to disturbance: $p = 0.506$).

3.2. Personal Experience with Flooding

Most respondents indicated that they did not have personal experience with flooding in the last 10 years (66%, $n = 166$). It should be noted that a majority of participants who had personal experience with flooding also aligned themselves with the resilience-based internal representation of how the system should be managed (73%, $n = 62$) compared to those who did not have personal experience (49%, $n = 82$; $p < 0.001$). Internal representations associated with the ecosystem's connectedness and response to disturbance were not affected by personal experience with flooding ($p = 0.545$ and $p = 0.395$, respectively).

3.3. Regional Resilience to Flooding

Respondents perceived their region to be sufficiently resilient to flooding with 64.9% ($n = 111$) in agreement. There were no significant relationships with perceptions of a region's resilience and internal representations of the system (Table 2). When asked about reasons for their region's resilience or lack thereof, consistent with the distribution of these responses, individuals listed similar reasons such as infrastructure and governance/management practices (see Table S2).

Table 2. Distribution of perception of regional resilience to flooding by resilience/resistance-based internal representations ($N = 171$).

Question	Resilient		Not resilient		*p*-Value
	Resistance	Resilience	Resistance	Resilience	
Connectedness	1.2% ($n = 2$)	63.7% ($n = 109$)	1.2% ($n = 2$)	33.9% ($n = 58$)	0.439
Response to disturbance	21.6% ($n = 37$)	43.3% ($n = 74$)	8.8% ($n = 15$)	26.3% ($n = 45$)	0.170
Management approach	30.4% ($n = 50$)	34.5% ($n = 59$)	11.7% ($n = 20$)	23.4% ($n = 40$)	0.060

3.4. Preference for Governance: Actors

A combination of the three sectors (*i.e.*, governments, citizens/NGOs and the private sector) as well as involvement of governments alone were the most desirable options during the immediate flood response phase. Involvement of the private sector alone was rated to be the least desirable option (Table 3). Individuals who supported the resistance-based approach to management of the system rated governance by governments slightly higher compared to those who supported the resilience-based view. Personal experience with flooding also had very little effect on the preference for who should be governing. There were no other significant differences in preference for governance actors based on perceptions of system's connectedness, response to disturbance, management approach or personal experience (see Table 3).

Table 3. Average desirability ratings for governance actors by resilience/resistance-based internal representations of the system.

	Government	Citizens/NGOs	Private Sector	Governments & Citizens/NGOs	Governments & Private	Citizens/NGOs & Private	Combination of All
Connectedness							
Resistance-based	5.87	2.13	2.40	5.67	3.60	3.07	5.00
Resilience-based	5.66	2.42	1.90	5.11	4.20	3.17	5.67
p-value	0.910	0.508	0.971	0.263	0.269	0.825	0.118
Response to disturbance							
Resistance-based	5.92	2.46	1.93	5.05	4.22	3.16	5.51
Resilience-based	5.55	2.39	1.90	5.16	4.16	3.17	5.71
p-value	0.146	0.822	0.941	0.516	0.930	0.684	0.507
Management approach							
Resistance-based	**5.90**[1]	2.32	2.07	5.00	4.21	3.16	5.53
Resilience-based	**5.50**	2.47	1.80	5.21	4.16	3.17	5.73
p-value	**0.050**	0.314	0.073	0.077	0.741	0.984	0.371
Personal experience							
Yes	5.78	**2.74**	1.83	5.16	3.99	3.15	5.38
No	5.61	**2.23**	1.96	5.10	4.28	3.18	5.79
p-value	0.177	**0.004**	0.068	0.887	0.087	0.711	0.182

[1] Bold values are statistically significantly different.

Table 4. Average desirability ratings for governance mechanisms by resilience/resistance-based internal representations of the system.

	Government Regulations and Policies	Community-Based, Participatory Approaches	Market-Based Mechanisms Such as Environmental Taxes and Tradable Permits	Cooperative Agreements and Joint Management between Government and Citizens/NGO	Market Incentives and Self-Regulation Arrangements between Government and Private Businesses	Pressure from the Public and NGOs on Private Businesses to Change Practices	Combination of All
Connectedness							
Resistance-based	4.42	4.33	3.00	4.75	3.33	2.17	6.00
Resilience-based	5.36	4.11	3.26	4.16	3.18	2.60	5.53
p-value	0.171	0.783	0.645	0.434	0.825	0.520	0.618
Resistance-based	5.45	3.92	3.16	4.20	3.36	2.58	5.56
Resilience-based	5.29	4.19	3.30	4.17	3.11	2.59	5.53
p-value	0.483	0.218	0.461	0.974	0.222	0.963	0.784
Resistance-based	5.56	4.06	3.14	4.18	3.47	2.54	5.39
Resilience-based	5.17	4.15	3.34	4.17	2.98	2.62	5.65
p-value	0.055	0.506	0.484	0.909	0.007	0.520	0.207
Personal experience							
Yes	**5.68**[1]	3.99	**2.91**	**4.61**	**2.88**	2.59	5.35
No	**5.14**	4.18	**3.45**	**3.94**	**3.35**	2.58	5.64
p-value	**0.010**	0.389	**0.043**	**0.032**	**0.029**	0.913	0.180

[1] Bold values are statistically significantly different.

3.5. Preference for Governance: Mechanisms

Similar to preferences for who should be governing, the respondents rated use of "government regulations and policies" as well as "combination of all three approaches" as most desirable (Table 4). "Pressure from the public and NGOs on private businesses to change practices" was the least preferred approach to flood management. Personal experience with flooding was the only variable that had an effect on the preference for governing mechanisms such that individuals with personal experience preferred the use of "government regulations and policies" and "market-based mechanisms" slightly more compared to those without experience. Those without personal experience rated use of "cooperative agreements and joint management between government and citizens/NGO" and use of "market incentives and self-regulation arrangements between government and private businesses" significantly more desirable compared to individuals with personal experience. There were no other significant differences in preference for governance actors based on perceptions of a system's connectedness, response to disturbance, management approach or personal experience (see Table 4).

3.6. Flooding as a Catalyst for Change in Governance

There was an almost equal divide between respondents' perceptions of flooding as a catalyst for change in governance, such that 50.9% (n = 87) agreed with the statement and 49.1% (n = 84) disagreed. There were no significant differences in perceptions of flooding as a catalyst for change based on internal representations (*i.e.*, perceptions of connectedness (p = 0.324), system's response to disturbance (p = 0.375), management view (p = 0.066) or personal experience with flooding (p = 0.430)).

4. Discussion

While elicited in the context of flooding, a strong majority of respondents expressed that their views would remain constant for other disturbances. This suggests that access was indeed gained to foundational views that transcend flooding, and at least extend to other natural hazards. In consideration of how respondents view the system, an overwhelming majority hold internal representations emphasizing the connectedness of all components (abiotic, biotic, and social). With respect to the manner in which systems function, a majority framed the response to disturbance in terms of change associated with complexity and uncertainty. These two internal representations developed and held by respondents resonate soundly with 'nature evolving' caricature of nature (sensu Holling *et al.* [19]), reflect emerging scholarship on complex adaptive systems [29,41], and the connectedness of social and ecological systems [30,42]. Empirical support is specifically furnished for the emergent connection between the presence of these foundational views in relation to flooding [8,10,43].

Internal representations held by respondents about how the ecosystem operates in relation to flooding are salient insofar as implications for action, policy and other interventions [18,19]. Two disparate views emerged in relation to flood management. Nearly half of the respondents (47.4%) held the view that stakeholders must work together to define the issues and its boundaries because everyone sees the system differently whereas others (42.2%) contended that managing flooding should occur by isolating and managing issues separately. In considering these dichotomous views on management, along with the minority and majority views regarding the connectedness of system components as well as system response to disturbance, evidence emerges of the existence of both resistance-based and resilience-based approaches. Methodological challenges exist in identifying mutually exclusive indicator characteristics for internal representations of the system, and this may have contributed to the alignment with more than one internal representation by many respondents. Personal experience with any form of flood damage during the past decade significantly influenced views on management, where a majority of respondents who endorsed the 'resistance-based' paradigm had no personal experience with flooding. The presence of both these paradigms in the responses may be indicative

of the evolution of flood mitigation as described by Schanze [6]. This lends support to the prospect of resilience as a third paradigm (following flood protection and risk management, sequentially) for flood mitigation [6]. The findings from this research support mounting arguments for a transition from flood risk management to a resilience-based approach [7–11].

A majority of respondents agreed that their region was sufficiently resilient to flooding and no significant relationship was found with the underlying internal representations held by respondents, as represented by the two approaches (*i.e.*, resistance-based and resilience-based) to flooding. However, resilience was explicitly framed in terms of a resilience-based approach for this question in the survey [30]: the ability to withstand disturbances, or adapt to them, or transform when needed to maintain a desirable system including ecological and human (social) dimensions. This reinforces the notion that paradigms of flood management may co-exist and that each new paradigm may enhance the preceding ones, moving from flood protection, to risk management, to a potential third, new paradigm of resilience [6]. Reasons why regions were considered resilient (or not) were often similar or even identical. For example, in all five cases respondents mentioned infrastructure (as one of the top three most frequently identified reasons) as evidence of regional resilience and evidence against it. Similarly, governance was identified as a reason for resilience in four cases and also identified as an inadequacy in three cases (with some cases citing both). These responses support and highlight the co-existence of flood management paradigms at a point in time as an evolution occurs. The evolution of approaches to flooding complicates and extends the resources and means to build capacity for resilience to flooding. In their investigation of evolving water paradigms and the roles of capitals in building capacity to flood management, Plummer *et al.* [43] found that an 'old' water paradigm focused on engineering/infrastructure solutions to flooding problems that emphasized built and financial capital existing in the past. The importance of these capitals has persisted but social and human capitals have gained prevalence as a "new" paradigm appears to be emerging. This new water paradigm allocates capital in a different way, focusing instead on "building capacity from a dynamic and integrative systems paradigm" [43], and is aligned with principles for enhancing the resilience of ecosystem services [44] as well as the tension between promoting specified resilience (ability to respond to a particular, known disturbance) and general resilience (building capacity to respond to any and all disturbances including surprises) [45].

Flood governance is a quickly growing area of scholarship and concern for policy makers. The relationship between disastrous floods and responses in policy is well established (see Johnson *et al.* [46]. Persistent and severe floods in Europe have precipitated a shift from flood protection to flood risk management, and ultimately, manifest in the Floods Directive of the European Union [47,48]. Instances of flooding catalyzing changes in governance are diverse and examples among them include particular regions of Germany [49], Canada and Australia [43], and Senegal [50]. While all respondents were from flood-prone areas, they were almost equally divided when asked if flooding has acted as a catalyst for governance change in their region. Interestingly, consensus was not evident from respondents in any of the regions, nor were significant differences revealed in terms of underlying views held, or experience with flood damage in the past decade. These same stakeholders also held differing views on how flooding in their region was currently governed [15]. The foregoing highlights the importance of perception data from stakeholders in relation to flood governance and bolsters broader arguments by Kaufmann *et al.* [51] that such "subjective" information needs to be considered in relation to 'objective' data in gaining a complete picture of governance.

Governance preferences were queried in terms of the actor(s) engaged in decision-making as well as the mechanism(s) for implementation. The desirability of who should be responsible for governance as well as the approach believed to be most effective in encouraging sound flood management practices during each stage of flooding (preparation, immediate response, recovery) are presented by region in a companion piece (see Plummer *et al.* [15]). A major thrust of this research was to probe the relationship(s) between the internal representations held by individuals, specifically according to contemporary thinking about floods, and their desired outlook for flood governance. Individuals,

across all stages of flooding and regions, rated governments alone, or in combination with other actors (citizens/non-governmental organizations, private sector) as most desirable and the private sector alone as the least desirable. In terms of the most effective means in encouraging sound flood management practice, individuals consistently rated governmental regulations and policies or a combination of mechanisms (government regulations and policies, community-based participation and market-based together) as most desirable and the private sector (along with it in combinations with other mechanisms) as least desirable. No significant relationships were found between the internal representations (resistance- or resilience-based) and either of the aspects of governance.

Grounded speculation as to the reasons for this finding is two-fold. The construct of resilience, given prominence through distinct ways of thinking about floods, was central to gaining insights about foundational internal representations as to how ecosystems operate in relation to flood disturbances and how they should be managed. Use of resilience in this manner and the specific questions were arrived at through a multi-year, iterative process of revision—drawing extensively on scholarly literature [34], applying the developed typology in multiple contexts using context analysis and survey approaches [21,35], and making refinements. While conceptually sound and intuitively appealing, individuals in this research appeared to find particular aspects heuristic, as opposed to a comprehensive view. This finding corroborates simultaneous observations that question the universality of resilience as a framing concept or paradigm in relation to disaster risk reduction [52] and more broadly [53]. Second, this research concentrated on worldviews in relation to flood governance. The variability of internal representations held, combined with the relatively strong agreement about who should be responsible and how floods should be governed, confirms that this is a transitory time in how individuals are thinking about floods. It also suggests that a myriad of other influences shape the outlook on flood governance. Support for this conjecture comes from the recent work on governing through resilience in relation to flood protection by Hutter *et al.* [54]. Stemming from their application of the governmentality to resilience and flood risk management they urge broad empirical investigations that are context specific.

5. Conclusions

Serious risks are associated with floods worldwide. Floods regularly comprise some of the most disastrous events each year [55,56]. Flood risk globally is projected to increase due to climate and non-climatic drivers [3–5]. Given the present and future gravity of flood risks, it is of little surprise that mounting attention is being directed to how such disasters are, and should, be approached. A transition is underway in contemporary thinking about flood management from a resistance-based approach to a resilience-based approach [8,10,11,43]. Scholarly arguments for this shift share similarities to those in complex resource systems (see Holling *et al.* [19]—they encompass foundational views about how nature operates and its management with implications for societal steering and interventions. This research sought to illuminate the views of stakeholders in flood-prone regions and probe the relationship to preferences of flood governance.

The multiple case survey administered in five countries provided insights into aspects of the internal representations held by individuals of the system and views about flood management. The findings reinforce connections being made in the literature between foundational views and contemporary thinking about floods [8,10,43] as well as supporting the evolutionary perspective of flood management [6] in which emerging paradigms enhance preceding ones. No significant relationships were found between the resistance-based and resilience-based approaches in terms of who should be responsible for flood governance or the means by which intervention should occur. This finding prompted critical discussion about the universality of resilience as a framing construct as well as additional considerations shaping stakeholders' views and preference for flood governance.

The IPCC SREX report [4] (p. 68) emphasizes that "vulnerability in the context of disaster risk management is the most palpable manifestation of the social construction of risk . . . " and this encompasses "how human perception, understanding, and assimilation of the factors of risk influence societal reactions, prioritization, and decision making processes". This research study offered key insights specifically related to flooding. In building upon it, there are opportunities to pursue the use of mental models through other techniques to more fully understand how individuals think about floods and therefore act, as broadly identified in natural resources management by Jones *et al.* [18]. The call for undertaking context-specific investigations of resilience and flood governance by Hutter *et al.* [54] that takes into account multiple rationalities and changing modes of governmentality, is supported and informed by this work. Masud [57] observes that human dimensions (knowledge, values, interests) are often identified in disaster management but the process by which they are brought together is underdeveloped. This is an important frontier for disaster governance and we echo earlier arguments by Kaufmann *et al.* [51] that perceptions of stakeholders have an important role. This is emphasized by the dual focus on infrastructure as a perceived reason for resilience and also supporting a lack of regional resilience in this study. Above all else, this study elucidates the diversity of views and preferences held by stakeholders in flood-prone areas and reinforces the need to carefully consider their meaningful engagement in addressing flooding now and in the future.

Supplementary Materials: The following is available online at www.mdpi.com/2073-4441/8/5/191/s1, Table S1: Response rates; Table S2: Reasons given for and against resilience of the region to flooding.

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

Appendix

1. Have you had any personal experience with flooding in the last ten years (any form of flood damage, including damage to your home, vehicle, or garden)? (Yes/No)

Preamble

Ecosystems, in the broadest sense, can be considered to include abiotic components (that is, components that are not living, such as geological forms and water) and biotic components (that is, components that are living, such as plants and animals). We can also consider social components (that is, humans and their interactions, such as individuals and cultural groups) as a separate sub-component of the biotic component. We are interested in understanding how you view the linkages among these broad components.

2. Please select the one statement that best represents your view:

Ecosystem components are not connected and each can be considered separately	□
Abiotic and biotic components of ecosystems are connected; however, the social component (humans) are separate	□
All components of ecosystems are connected (abiotic, biotic, social)	□
How the ecosystem is defined (and what components are included) is entirely dependent on the reason for defining it and who defines it	□

3. Considering flooding as a "disturbance", how would you describe a resilient ecosystem? (choose the one statement that best represents your view)

The ecosystem can resist changing and return quickly to its initial set of conditions	□
The ecosystem can adapt and basically maintain a stable set of conditions that may vary a little from the initial set of conditions	□
The ecosystem can adapt, but outcomes from a disturbance can be unpredictable, therefore, adaptation is often complex and uncertain	□
The ecosystem is inherently unstable, so outcomes are always changing and unpredictable	□

4. What is your view on managing the ecosystem?

We can isolate and manage issues separately	□
We can focus on ecological problems and manage the ecosystem separately from the social system	□
We must consider the social, economic, political and environmental aspects of issues	□
Everyone sees the system differently and stakeholders must work together to define the issue and its boundaries and manage issues collaboratively	□

5. If you were asked about a different disturbance (other than flooding), would your responses to the above questions be different? (Yes/No)

Preamble

The questions in the following section ask you to identify how you would rank who should be involved in governing and what approaches are most effective during three time periods: flood preparation, immediate flood response, and flood recovery. Note that flooding and flood management has several dimensions (e.g., ecosystem, economic, infrastructure, health-related dimensions). Please consider all dimensions of flooding when providing responses for each time period below.

6. Considering the following actors and combinations in relation to governance, please rank the seven options from most desirable (1) to least desirable (7) for each time period (flood preparation, immediate flood response, and flood recovery). Keep in mind that we are interested in your personal view.During flood preparation, which group(s) should be responsible for governing?

Governments
Citizens and non-governmental organizations
The private sector
A combination of government and citizens/non-governmental organizations
A combination of government and the private sector
A combination of the private sector and citizens/non-governmental organizations
A combination of governments, citizens/non-governmental organizations, and the private sector

7. During immediate flood response, what approach(es) are most effective in encouraging sound flood management practices?

Government regulations and policies
Community-based, participatory approaches
Market-based mechanisms such as environmental taxes and tradable permits
Cooperative agreements and joint management between government and citizens/non-governmental organizations
Market incentives and self-regulation arrangements between government and private businesses
Pressure from the public and non-governmental organizations on private businesses to change practices
A combination of government regulations and policies, community-based participatory approaches and market-based mechanisms

8. Do you think your region is sufficiently resilient to deal with flooding when it occurs? (Yes/No)

    a) If you answered 'Yes' to the previous question, what resources/characteristics make your region resilient to flooding? (Examples: specific governance attributes, infrastructure in place, ecosystem attributes). Please provide an example to support your response.
    b) If you answered 'No' to the previous question, what resources/characteristics are lacking? (Examples: specific governance attributes, infrastructure in place, ecosystem attributes). Please provide an example to support your response.

9. Do you think that flooding has acted as a catalyst for a change in governance in your region? (Yes/No)

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