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Veröffentlichungsversion / Published Version

Zeitschriftenartikel / journal article

#### Empfohlene Zitierung / Suggested Citation:

Dauids, P. R., & Thaler, T. (2021). Flood-Resilient Communities: How We Can Encourage Adaptive Behaviour Through Smart Tools in Public-Private Interaction. *Urban Planning*, 6(3), 272-282. <https://doi.org/10.17645/up.v6i3.4246>

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Article

## Flood-Resilient Communities: How We Can Encourage Adaptive Behaviour Through Smart Tools in Public–Private Interaction

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Submitted: 3 March 2021 | Accepted: 28 April 2021 | Published: 19 August 2021

### Abstract

To achieve a more flood-resilient society, it is essential to involve citizens. Therefore, new instruments, such as tailor-made advice for homeowners, are being developed to inform homeowners about adaptive strategies in building to motivate them to implement these measures. This article evaluates if public–private interactions, such as tailored advice, change risk behaviour and therefore increase flood resilience among homeowners. The article conducted semi-structured interviews with homeowners who had received advice as well as involved experts in two case study regions in Europe: Flanders in Belgium and Vorarlberg in Austria. The results show how the tailored advice helps homeowners who are already aware of flood risks and provides them with answers on how to adapt a house. However, the tool seems to lack the ability to inform and “recruit” new groups of homeowners who are not as familiar with flood risks. As such, this article concludes that this initiative has a relatively low impact in raising flood risk awareness among homeowners but may be more successful in serving as a tool that suggests tailored property-level flood risk adaptation measures for those who are already aware. Alternatively, more automated tailored information systems might be more efficient for unaware homeowners.

### Keywords

Austria; Belgium; flood risk management; homeowners; property level flood risk adaptation (PLFRA); risk governance; tailored risk communication

### Issue

This article is part of the issue “Smart Urban Governance for Climate Change Adaptation” edited by Thomas Thaler (University of Natural Resources and Life Sciences, Austria), Patrick Witte (Utrecht University, The Netherlands), Thomas Hartmann (TU Dortmund University, Germany) and Stan Geertman (Utrecht University, The Netherlands).

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### 1. Introduction: A Behavioural Turn in Flood Risk Management

Flood hazards that are caused due to exceptional rainfall events lead to severe damage in European urban areas (Alfieri et al., 2015; Field et al., 2012), and climate models predict an increase of such events in the coming decades (Intergovernmental Panel on Climate Change, 2018). Governments traditionally try to reduce the probability of flood events with solutions such as dikes and other technical solutions. However, the increase and unpredictability of floods leads to an increased complex-

ity of flood risk management, as governments can no longer guarantee “dry feet” for their citizens based on governmental interventions (Meijerink & Dicke, 2008; Rauter et al., 2020). Based on the principles of resilience (Fekete et al., 2020; Folke et al., 2010; Liao, 2012), governments in the present day strive for a more holistic risk-based approach that includes uncertainties (Kuklicke & Demeritt, 2016), planning (Hartmann & Juepner, 2014), and the involvement of civil actors (Forrest et al., 2020; Seebauer & Babicky, 2018). These new actors, such as homeowners, are becoming part of flood risk management as they can reduce their personal vulnerability

(e.g., Kuhlicke et al., 2020; Mees et al., 2016; Rufat et al., 2020; Snel et al., 2020). Consequently, flood risk management requires collaborative planning for public administration. Sharing responsibility is becoming more and more common (Begg et al., 2017; Butler & Pidgeon, 2011). Influenced by these developments, flood risk management is becoming more adaptive, flexible, and dynamic (McClymont et al., 2019). As such, new actors get involved and traditional strategies diversify with new approaches, strategies, and instruments in the field of flood risk management (Hegger et al., 2016).

New actors, such as homeowners, are asked to actively participate in flood risk management because their actions can reduce potential losses in and directly around their houses and impact their vulnerability. One of the main reasons for this change of perspectives is that the government is not able to reduce risks to zero. To reduce the remaining risks (such as residual risk or lack of structural engineering solutions to protect communities) homeowners need to contribute to the solution (Kreibich et al., 2005). Therefore, in recent years, new approaches, strategies, and instruments have appeared to inform and motivate residents about their flood risks, their responsibilities, the need for adaptation, and which things can be adapted. Examples of strategies include, among others, flood risk mapping (Van Alphen et al., 2009), participatory projects (Begg, 2018), inter-regional co-operation (Thaler et al., 2016), and strategies to target direct or indirect implementation of property level flood risk adaptation (PLFRA, which includes (1) wet-proofing—controlled flooding and the adaptation of interiors, (2) the avoidance of flooding—e.g., stilts or floating structures, and (3) dry flood-proofing—e.g., watertight basement windows, etc.; Attems, Thaler, Genovese, et al., 2020; Gersonius et al., 2008). Among individual homeowners, strategies include recovery financing linked to future damage reduction (Slavíková et al., 2021), flood labelling for houses (Hartmann & Scheibel, 2016), a duty to inform during housing transactions (Mees et al., 2018), and tailored expert advice for homeowners (Davids et al., 2019). All these strategies can contribute to a behavioural turn among citizens in flood risk management (Kuhlicke et al., 2020), as these strategies: (1) try to understand and influence the willingness to act, (2) inform about the effectiveness of PLFRA measures, and (3) support homeowners on the implementation of these measures. For example, a homeowner could reduce potential damage by removing valuable furniture or moving the kitchen from the basement to the first floor, or by the installation of bulkheads and pumps. Moreover, based on an effectiveness/efficiency analysis, sometimes interventions at the local level (for example in residential buildings) are preferred over extensive spatial interventions (Hoss et al., 2011; Kaufmann et al., 2016). Consequently, this makes flood risk management no longer a solely governmental activity, as citizens can have an active role using PLFRA measures and therefore reduce flood damage (Mees et al., 2016; White et al., 2018). However, the uptake

of these measures by homeowners is still low (Attems, Thaler, Genovese, et al., 2020; Grothmann & Reusswig, 2006; Kellens et al., 2013; Rözer et al., 2016). There are various explanations as to why homeowners still refuse or struggle to implement PLFRA measures. One key problem is that homeowners are not always aware of their flood risks (Thistlethwaite et al., 2018). Further, homeowners often lack information on how to implement PLFRA measures in their houses (Attems, Schlögl, et al., 2020). Aside from that, homeowners often seem unwilling to take measures as they perceive flood risk management as a governmental task or they do not have the legal rights, know-how, or financial savings to implement PLFRA measures (Botzen et al., 2013; Bubeck et al., 2012; White et al., 2018). So, there is a gap: Governments expect homeowners to participate in local flood risk management, but these homeowners are not always conscious or able to or willing to change their behaviour. This lock-in situation between government and homeowners is happening more often, and more interactive and collaborative approaches in risk communication are desired (Mees et al., 2018; Tasantab et al., 2020). The aim of the article is to address if new instruments in risk communication, such as using smart technologies, are more effective in informing and encouraging homeowners of how to implement PLFRA measures at home. An example of such smart technologies is tailored advice for homeowners. This is a tool to evaluate flood risk levels at home and provides suggestions to reduce these risks with solutions tailored to the characteristics of a specific home. As such, this tool seems to focus more on providing information and triggering adaptive behaviour than on awareness-raising. These suggestions can be automatically calculated, and in some cases additionally explained by a flood risk expert. Such smart technologies have become a more crucial aspect in flood risk management in the past few years (Neubert et al., 2016; Ran & Nedovic-Budic, 2016; Schinke et al., 2013). Smart technologies in flood risk management include two directions: (1) the innovation of new technologies in terms of PLFRA measures (White et al., 2018) and (2) information and communications technology (ICT), such as the use of artificial intelligence or new forms of communication (Attems, Thaler, Snel, et al., 2020; Kratzert et al., 2019). The advantages of using smart technologies in flood risk management are the ability to use the latest ICT innovation to reach a wide range of different people with a standardised approach (Jiang et al., 2020a, 2020b). The literature addresses the advantages of smart technologies in terms of including multiple actors at multiple political levels as well as the ability to interact within these smart technologies (Kummitha & Crutzen, 2017; Neirrotti et al., 2014). There are various examples of using smart technologies in urban planning (see, e.g., Geertman & Stillwell, 2020). Nevertheless, the use of smart technologies highly depends on the willingness of people to accept and interact with the tools (Greenfield, 2013). In addition, the tools often lack certain flexibility within the design level

to include the special needs of communities. For example, the housing stock in Belgium, Germany, Austria, or Switzerland shows more variety due to their individualistic designs and constructions, compared to the uniform prefabricated housing stock in countries such as the Netherlands and the UK. These varieties among individual houses result in more specific questions on risk reductions among the homeowners.

To explain if smart technologies such as tailored advice are more effective in informing and encouraging homeowners, and to analyse what factors influence the level of success of the pilots, this article uses Boelens' (2018) actor-relational approach. The actor-relational approach provides a wider perspective of spatial planning actions. The framework includes "other forms of independent action, within the business sector, the institutional community, and in everyday life" (Boelens, 2020, p. 11). This approach is able to analyse the relations and co-evolutionary interaction among factors, actors, and institutions, instead of the factors, actors, and institutions themselves (Boelens, 2010; Boelens & de Roo, 2016). When considering behavioural change of homeowners in flood risk management, we need to also consider changing behaviour of other actors and contextual factors (Davids et al., 2019). This approach offers the opportunity to analyse how tailored advice leads to institutional innovation and more specifically, to behavioural change. Therefore, in the next section and based on the structure of factors, actors, and institutions, this article considers the following research questions:

- Which contextual factors, actors, and institutions determine the use of smart technologies, such as tailored advice, in flood risk management?
- Can tailored advice encourage a behavioural change of homeowners to increase their resilience to flood hazards?
- To what extent does tailored advice result in improved community resilience at a larger scale?

In this article, we compare two international cases of these tailored advice practises, as examples of new smart technologies because it combines standardised methodologies with in-depth analyses of a house. In Belgium, we will consider a pilot that has been running in the region of Flanders, organised by the Flanders Environmental Agency. In Austria, we consider the pilot from the region Vorarlberg, organised by the regional authority in close cooperation with blue light organisations, such as the fire brigade, and insurance sector. Whereas the Belgian experiment is considered to be successful and is starting a third pilot in 2020–2021, the Austrian experiment was mostly suspended after one pilot. We are wondering what factors influence the level of success of the pilots and what factors are limiting. Here, we assume contextual factors make a difference. To clarify this statement, we will use the actor-relational approach on tailored expert advice in flood risk management.

## 2. Flood Risk Management as a Relational System

Behavioural change of homeowners in flood risk management can be considered as highly dependent on social and institutional contexts. Therefore, homeowner involvement in flood risk management is highly relational (Davids et al., 2019). The theoretical starting point of this article forms Luhmann's (1995) systems theory of social innovation. One cannot observe a society from the outside in its totality, only from within. However, perceived from within, these observations are too complex, interactive, and volatile. To reduce the complexity, Luhmann's distinct subsystems each have their own codes of conduct, behaviours, actors, and contexts. These interact and shape the subsystem, but also interact with other subsystems, forming a relational system where interactions cause new interactions. Through these interactions a subsystem evolves and evolves and evolves, and, as such, is always in a state of becoming (Boelens & de Roo, 2016). This leads to multiple institutional innovations happening in various directions and all happening at the same time: expanding, renewing, and innovating over and over as adaptations on the existing context (Boelens, 2018). To grasp this black box of evaluating institutions, Boelens (2018) distinguishes factors of importance, actors, and institutions that co-evolve together (see Figure 1):

- Factors of importance include elements such as geography and infrastructure. In the subsystem of flood risk management, examples of these factors include climate change, floods, risk, and the availability of structural and PLFRA measures.
- Institutions are the formal and informal codes of conduct in a subsystem. In the subsystem of flood risk management, examples include agreements on responsibility and accepted levels of residual risk.
- (Leading) actors of a subsystem include governmental, business, and civil actors. In the subsystem of flood risk management, examples include governmental flood risk managers, local leaders of citizen groups, insurers, and companies involved in PLFRA implementations.

Together, these three components and their interactions shape subsystems as we know them but are also able to interpenetrate or irritate other subsystems, which in turn can innovate and evolve (Boelens, 2018).

This system of co-evolutions is one that we recognize in flood risk management as well. As the system of flood risk management is facing more floods that have left more damage over the past few decades (new factors of importance), governments make an appeal to homeowners to take responsibility for their houses (new leading actors are invited to participate). Also, new formal and informal agreements are formed to share the responsibility of flood risk (new institutions). These innovations

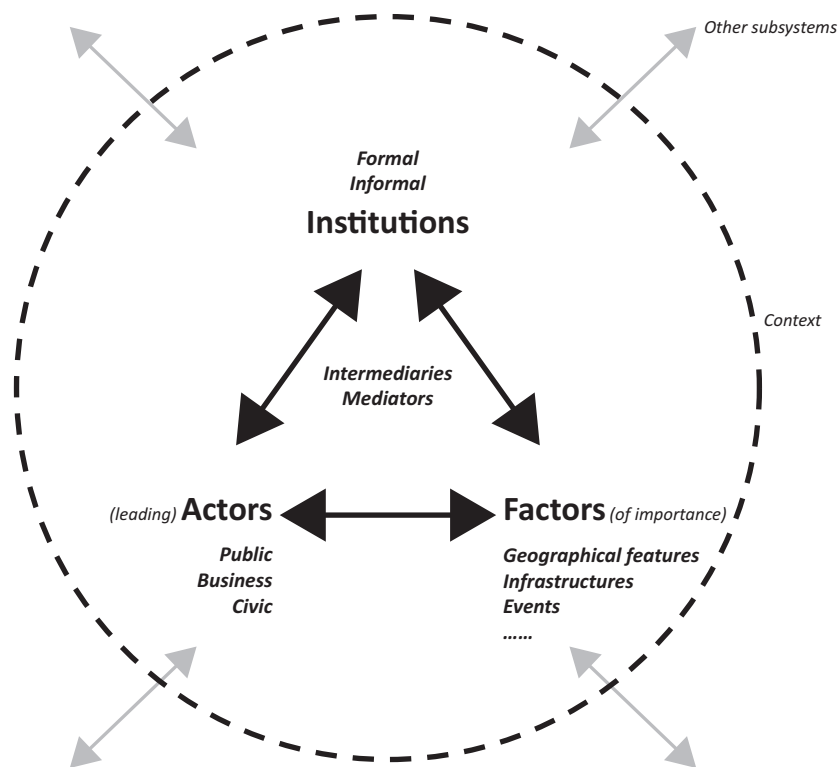


Figure 1. Scheme of an actor-relational subsystem. Source: Boelens (2018, p. 96).

influence each other back and forth and result in a new evolution being born.

Influencing this continuous interactive evolution is complex. The outcome of interventions cannot be predicted and directed due to the volatile and dynamic nature of the interactions. However, Healey (2007) highlights how, in this case, flood risk managers should be skilled to take the pulse of these interactive dynamics and generate opportunities for encounters. This is where tailored advice comes in, which can, in line with Boelens (2018), perform as an intermediary, transferring knowledge without changing it, or as a mediator, translating and aligning information mutually between factors, actors, and institutions, resulting in institutional innovation, in this case, a change of behaviour within the system. Using the actor-relational approach makes it possible to analyse the role of specific smart tools in the complexity of interrelations of flood risk management.

### 3. Methods

This article used a mixed-method design combining semi-structured interviews with national and regional authorities and citizens, analysis of policy documents, as well as phone interviews with citizens.

For the first study site in three towns in Flanders (Belgium), we conducted in total 14 semi-structured in-depth interviews; one interview with the project leader of the Flanders Environment Agency responsible for the pilot; and 13 interviews with homeowners that participated in the pilot. Homeowners were randomly selected

in the experts' agenda and interviews took place directly after the visit of experts. The semi-structured interviews were conducted in June and July 2017 and lasted between 60 and 75 minutes. Additionally, among all 209 participating homeowners a short telephone survey was executed. For this survey, a total of 175 out of 209 project participants were contacted. From these, 148 were willing to participate in the short telephone survey. The phone calls took about 10 minutes.

In the second study site of Vorarlberg (Austria), we conducted in total 18 semi-structured in-depth interviews; two interviews at the national level with experts from the national flood risk management policy, two experts at the regional level responsible for the implementation of the regional flood risk management strategy in the federal state of Vorarlberg, 12 interviews with homeowners, as well as two stakeholders from insurance and blue light organisations. The selection process of the sampling was one sided, based on the network between the researcher and researched as well as a snowball effect to recruit the sampling of the homeowners (Rauter et al., 2020). The semi-structured interviews were conducted between February and May 2018 and lasted between 30 and 120 minutes. The interviews were transcribed and coded within the software package f4 and NVivo.

For both studies, the themes that were covered in the interviews included experiences of past flood event(s), key actors in flood risk management, the role of various actors, barriers and drivers of the implementation of PLFRA, trigger points to implement PLFRA, interactions

with governmental actors and neighbourhoods (i.e., process, type of communication), funding (e.g., financial subsidies, bank loans, etc.), legal obligations and restrictions, reflections on the communication between homeowner and expert, and the role of ICT in the process.

For both studies, we used a grounded theoretical approach to analyse the interviewees, where the code was structured around the actor-relational approach by Boelens (2018). Moreover, we analysed the national and regional policy documents dealing with the implementation of the PLFRA measures as well as the regional and local legal regulations, such as planning, building codes, and emergency management. The aim of the policy analysis is to understand how the institutional framework is framed in both countries and how the two different institutional frameworks influence the use of smart technologies in flood risk management (Thaler et al., 2020; Wildavsky, 1969).

## 4. Results

### 4.1. Factors

The towns of Sint-Pieters-Leeuw, Geraardsbergen, and Lebbeke are located in the region of Flanders, in the Dender and Zenne valleys, west of Brussels. Situated in the urban fringe of Brussels, the towns attract citizens from the capital looking for cheaper private-owned single-family detached and semi-detached housing in a green environment. The combination of a hilly landscape, and an erosion-prone soil of sand and loam, ensures rapid precipitation drainage, and makes the areas vulnerable to pluvial flooding. Despite the presence of retention basins, these basins appear to be too small to prevent flooding throughout the whole valley in the case of extreme precipitation. Recent exceptional rain showers (e.g., 2010, 2014, and 2016) resulted in incoming water in underground garages or at ground floor level, damaging up to 600 houses in Sint-Pieters-Leeuw during the 2010 flood (Hydroscan, 2018). The main causes included rainwater runoff, the overflow of the local river, or the backflow of water from the public sewer. To reduce future damage, some homeowners had already implemented some provisional PLFRA measures.

The federal state of Vorarlberg is characterised as a rural/peri-urban region with a wide range of private-owned single-family detached buildings. The federal state is located in the western part of Austria, close to the countries of Germany, Liechtenstein, and Switzerland, where a large proportion of citizens commute to work as the average earnings are higher in comparison to Vorarlberg. The region also includes a high density of manufacturers, especially in the Rhine and Walgau valley. Before the Covid-19 pandemic, the region had strong economic growth rates, which attracted a high number of national and international citizens to relocate to the region. Further, the Walgau valley connects the main transport lines to Switzerland. However, a large number

of the residential and non-residential buildings can be found in floodplain areas, due to a lack of permanent settlement and economic prospective within the region. Mountain communities, such as in the Bregenzerwald, show a marked decline of the population and an increase of second-home residents. Consequently, Vorarlberg was affected by several flood events in the past 20 years, such as river floods, torrential floods, debris flow, surface runoff, or groundwater flooding. In particular, the 2005 flood event caused high economic losses in the region as well as new policy concepts as a response to the event, such as encouragement of the implementation of PLFRA.

### 4.2. Actors

In federally organised Belgium, flood risk management is predominantly regionally organised. Only emergency planning and recovery and insurance policy are organised on a national level. For the management of floods, the region of Flanders distinguishes responsibility based on navigability of waters. Navigable waters are a responsibility of the regional Department of Mobility and Public Works; flood alleviation in non-navigable water is a responsibility of Flanders Environment Agency. Coordination between these two departments and municipal, provincial, and regional actors is organised by the Commission on Integrated Water Policy. Flood recovery compensation after a flood event is covered in household or fire insurance. If the insurance is not covered (e.g., when a flood is acknowledged as national disaster), homeowners can submit a claim with the federal disaster fund, and decisions on disbursements are made on a regional level.

As these governmental actors are not always able to prevent flooding, Flanders Environment Agency funds and organises tailored expert advice for homeowners to motivate the implementation of PLFRA. The case study that is considered for this article entails a pilot among 210 homeowners that ran from 2017 to 2018 in the municipalities of Sint-Pieters-Leeuw, Lebbeke, and Geraardsbergen. Previously, between 2013 and 2015, a first pilot ran among 85 homeowners living in Beersel and Sint-Genesius-Rode. A third pilot to advise about 150 households will be running in the town of Moelingen, and in municipalities along the brooks of Zwalmbeek and Kerkebeek in 2020 and 2021.

The Flanders Environment Agency uses an active strategy to recruit participants. This recruitment campaign started with an invitation letter that was sent out to everyone in flood-prone areas within the municipality as well as announcements in local newspapers. In both the letter and announcement, a reference to a website was made providing background information on the project and project process. The website also provided registration for a first general meeting in the community centre. Besides personal details, the registrant had to provide information on their flood risk experience and tenure status. From the 300+ registrations, the agency



selected 210 homeowners that suffered the most based on recent flood data from the fire brigade.

The advising process included a meeting between a homeowner and two experts at home. One expert has a background in loss-adjusting for insurance, and the second has expertise in urban water management. During a house visit, the experts collected data for the final report, which contained information on recent flood damage, building features, position of the house on flood risk maps, insurer details, overview of measures already taken, photos of the house and surroundings, and a list of proposed PLFRA measures and an estimation of the costs. In a final meeting between homeowner and experts in the city hall, these final reports were presented, clarified, and discussed between the expert and homeowner. In most cases the experts advised on the introduction of a pump to remove incoming water, floodwalls, backup valves, or a combination of these mentioned PLFRA measures. The estimated costs varied considerably from €500–600 for simple interventions such as a backup valve, and up to tens of thousands of euros for more complicated solutions. Almost half of the participants implemented (at least partially) the experts' advice on PLFRA: 32% from selected sampling implemented some PLFRA and 15% from selected sampling implemented all suggested PLFRA. Some homeowners have not yet implemented any PLFRA, but are still planning to, and a minority of homeowners is not willing to take further action for several reasons, including the costs of PLFRA and age of the homeowner.

The main actors in the Austrian flood risk management policy are two organisations: the national authority—Forest Engineering Service for Torrent and Avalanche Control (responsible for mountain hazards)—and the regional authority, the Federal Water Engineering Administration (responsible for river floods). Both organisations are responsible for the development of the policy framework in flood risk management, planning, and implementation of flood alleviation schemes in the region, providing hazard and risk maps, as well as contributing 80% of the costs for the realization of flood alleviation schemes. The local authorities are mainly responsible for the maintenance of flood alleviation schemes, contributing up to 20% of the costs of these, as well as for emergency management and land use management. The compensation scheme includes a mixture of private and public compensation, where the public administration provides a disaster-aid payment rate of up to 75% of the losses. The implementation of PLFRA measures is mainly in the hands of private landowners. Following the 2005 flood event, the region installed a temporary tailored expert position at the Regional Fire Brigade Association of Vorarlberg. The aim of the tailored expert position has been to inform homeowners how to implement PLFRA measures at their buildings. Initially this position was funded as a public–private partnership between public administration and the insurance sector.

Between 2013 and 2016 more than 80 homeowners received tailored advice from the Regional Fire Brigade Association of Vorarlberg. The recruitment was based on direct communications, newspapers, or presentations. Most homeowners acted on the recommendations made by insurance companies or the local fire brigade to take active PLFRA measures, others came directly to the expert based on newspaper articles, public presentations by the experts, or leaflets. However, most recruited homeowners had already implemented various PLFRA measures. A minority of homeowners implemented no further PLFRA measures after being given advice for several reasons, such as age—as some homeowners were already 70+ and did not expect any flood event in the near future—or the homeowners had high trust in the public flood alleviation schemes. Interestingly, financial restrictions played no role in the implementation or rejection of PLFRA measures. Nevertheless, the interviews stated that only a small number of homeowners in the region showed an interest in tailored expert advice (around 80 homeowners used the ability to interact with the office). This was also a main argument why the insurance sector left the partnership after this initial period. Using other communication channels failed as the homeowners requested face-to-face interactions with the Regional Fire Brigade Association of Vorarlberg.

#### 4.3. Institutions

The role of PLFRA measures plays a secondary perspective in the Austrian flood risk management policy. The key focus still lies on structural measures, such as dams or flood retention measures, across the country. The implementation of PLFRA measures (for already existing buildings) is mainly voluntary and is organised in Vorarlberg. Private property rights ensure that homeowners can freely make decisions about their property. This makes it so that public administration cannot force already existing buildings in hazard-prone areas to conduct any measures to reduce the losses from future flood hazard events. On the other hand, the public administration is also restricted by the law in providing financial subsidies to support homeowners to implement PLFRA measures. In terms of land use restrictions, the only influence is to design hazard-prone areas to avoid placing new residential and non-residential buildings in high-risk areas. Vorarlberg, for example, classifies “unfavourable natural circumstances” as a reason for land restriction, but does not provide a quantitative number, such as 1:100 (Rauter et al., 2019, p. 9). Additionally, the compensation regulation (after an event) does not provide any regulations or guidance to encourage homeowners to implement PLFRA measures (neither from insurance nor public administration). Consequently, the main activities are the provision of websites, newsletters, articles in newspapers, or public presentations by public administration that are strongly supported and managed by the tailored expertise of the Regional Fire Brigade Association of

Vorarlberg. However, the regional policy encourages the implementation of PLFRA measures, but not as the highest priority within flood risk management. Therefore, the project with the tailored expertise in the Regional Fire Brigade Association of Vorarlberg still exists, but it is limited in its activities as the insurance sector is no longer part of the project.

In Flanders, PLFRA gained more attention since the introduction of multi-layered water safety as policy discourse in 2013. This concept is the Flemish translation of the EU Floods Directive 2007/60/EC and aims to optimally combine measures of structural defence, spatial planning, and emergency planning in order to reduce risk in the region to a minimum. This approach emphasizes a multi-actor approach and suggests active involvement of water managers, spatial planners, the insurance, and construction sectors, as well as citizens. This has resulted in new tools and instruments to involve these sectors. To involve citizens, a “duty-to-inform” was introduced by the Flemish government in 2013 and indicates flood vulnerability levels of a property in real estate advertisements. For the Flanders Environment Agency, this policy discourse implies that homeowners could actively reduce residual risk, even though citizens generally expect the government to be exclusively responsible and able to avoid flood damage. Through these pilots, the agency wants to inform homeowners about this shared responsibility and about the homeowners’ ability to reduce flood risks. Moreover, as flood risk maps only provide information on the plot of a house—and not on the construction of the house—and as the government cannot enforce homeowners to implement any PLFRA, the agency started the pilots on tailored advice. The project leader stipulated that in the future they would like to involve more actors, such as insurers and construction industries, to develop related incentives such as modified insurance premiums. However, involvement in these pilots is limited to a generous subsidy scheme organised by province and municipality, which covers the costs up to 90% for the participants in Sint-Pieters-Leeuw (up to a maximum of €10,000). Yet, even with the subsidies, interventions did not happen more frequently when compared to the other two municipalities where limited or no subsidy options were available. Tailored technical advice therefore seems to have more effect than a generic subsidy policy.

## 5. Discussion and Conclusion

Smart tools to involve homeowners in flood risk management are being developed in many countries that include tailored expert advice. These tools might be able to communicate risk and influence homeowners’ behaviour (Attems, Thaler, Snel, et al., 2020). The results illustrate that homeowners become informed of risks and are encouraged to implement PLFRA, as the advice meets the characteristics of the behavioural turn (Kuhlicke et al., 2020) as well as explaining the effectiveness of PLFRA,

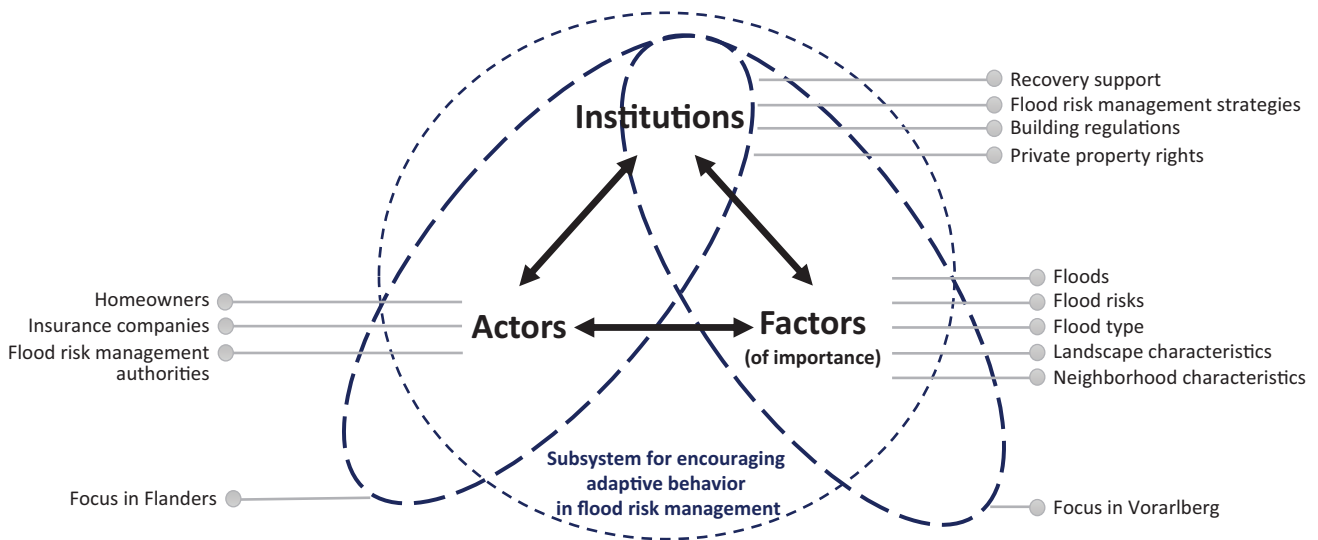
and the experts are able to support homeowners with tailored information. The comparison of these two case studies illustrates how different selection procedures—passive in Vorarlberg, and active in Flanders—result in similar groups of homeowners, namely those with flood risk experience.

However, Davids et al. (2019) propose a more relational approach when evaluating these tools, to find out if the advice is also serving as a mediating tool. To measure and explain the success of a tool, we should not only look at the levels of PLFRA implementation but consider contextual factors as well. These instruments do not function on their own, but their success depends on a context of factors, actors, and institutions that shape flood risk management.

The results show how the introduction of tailored flood risk advice, provided by an expert both in Flanders and Vorarlberg contributed to an uptake of PLFRA measures among homeowners. Nevertheless, the Flanders Environment Agency perceives their pilots as successful, while in Austria the activities have been suspended. Factors in both countries are similar. Both regions struggle with similar floods, and similar structural measures are implemented. Actors, however, differ. In Flanders, the pilot is perceived as a learning path and should lead to the involvement of multiple actors in the long run, while in Austria the experiment started as a cooperation between public authorities and the insurance sector, where the insurance sector withdrew before the advising finished. Institutions also differ. Homeowner involvement in Flanders is directly related to the multi-layered water safety approach, while in Austria the role of PLFRA seems more perceived as “an extra.” Also, the dynamic and highly fragmented flood risk governance in Flanders contributes to windows of opportunity for new developments in flood risk management in general (Mees et al., 2018), and for uptake of tailored advice as institutional innovation specifically. Austrian flood risk management, however, is more stable and does not encourage the introduction of PLFRA at all. Instead, the stability of the system predominantly supports a continuation of government-led engineered interventions that prevent flooding (Rauter et al., 2020).

Based on this comparison, this article concludes that tailored advice has a relatively low impact on raising flood risk awareness among homeowners, and it seems unable to recruit new people. As the tool only targets homeowners with high interest and some knowledge of flood risk, it seems to be more successful in serving to inform those who have specific questions and needs concerning PLFRA. As such, this tool can be perceived as successful, and it could be even more successful if the tool is perceived in a wider context that includes other actors’ behaviour. Nevertheless, the impact of the tool as a stand-alone remains limited. Alternatively, more automated tailored information systems, aimed at a larger less specific public, and that are less resource intensive, might be more efficient to inform the unaware





**Figure 2.** Scheme illustrating the dominant focus of both Flanders and Vorarlberg in encouraging adaptive behavior in flood risk management as an application of the actor-relational subsystem by Boelens (2018).

homeowners. In summary, the key question is if the costs outweigh the benefits, considering that these smart tools mostly involve and inform those who are already eager to implement PLFRA measures and not a broader target group, which is what is actually needed to reach the goal of improving the preparedness level of homeowners for future flood events. The personal interaction shows a “success” story in terms of increasing the preparedness level of the homeowners. However, this personal interaction relies heavily on face-to-face meetings, which are resource-intensive in terms of human resources, financial resources, and time needed within this process. Using a more ICT-oriented solution would not increase the behavioural turn of a larger group of homeowners as this article shows that homeowners request this face-to-face interaction.

The article adds to the current debate on how to increase flood-resilience in urban and rural communities (Fekete et al., 2020; Kuhlicke et al., 2020; Rufat et al., 2020). The focus on homeowners is essential as homeowners are a central factor in successfully reducing losses from future flood events (Attems, Thaler, Genovese, et al., 2020; Snel et al., 2020). Consequently, implementation of PLFRA measures have wide-ranging consequences for public administration and homeowners in terms of collaboration, who is responsible for what, who takes the risk of successful implementation, or who takes the lead of interacting and managing the process. Using the actor-relational subsystem helps us to understand how different factors (infrastructure, past events, geographical features), different actors (public, business, civic), and different institutional frameworks (formal and informal) influence the aim to reach a flood-resilient community. The Flanders example shows a stronger focus on the actor-institution relationship (see Figure 2).

The implementation of smart technologies is mainly driven by the institutional framework with the aim

to actively involve homeowners (and other private actors in general) and implement instruments at a larger scale. Consequently, the interaction (i.e., tailored advice) between the different actors needs a strong standardised interface. In contrast, the Vorarlberg example demonstrates a focus more on the relationship between factors and institutions (see Figure 2). The 2005 flood event encourages some new instruments and frameworks in the regional flood risk management system, where the implementation of PLFRA measures mainly becomes an additional goal for the public administration. The implementation of PLFRA measures is organised and managed as public–private collaboration between regional authorities, fire brigades, and the insurance sector. Nevertheless, PLFRA strategy was always seen as an “extra” strategy as the primary goal of the Vorarlberg flood risk management strategy is still based on engineering solutions (i.e., infrastructures), such as dams or flood storage. The minor role of PLFRA is mainly defined by the existing and planned infrastructure in Vorarlberg. In summary, the co-evolutionary interaction between factors, actors, and institutions shows the politically normative dimension of flood risk management and the potential role of smart technologies in flood risk management.

### Acknowledgments

This work was funded by the Austrian Research Promotion Agency (FFG) within the framework of the JPI Urban Europe project FLOODLABEL (Grant/Award Number: 693443) and Land4flood COST Action (Grant/Award Number: CA16209). We are grateful for the cooperative participation of the interview partners, as this was the basis for this analysis. Sincere thanks go to Paul Demuth and Mathias Peter for support in interviewing households. We would also like to thank the four anonymous reviewers for their insightful comments

on an earlier version of this manuscript. Open access funding was provided by BOKU Vienna Open Access Publishing Fund.

### Conflict of Interests

The authors declare no conflict of interests.

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