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The influence of tailored risk communication on individual adaptive behaviour

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ABSTRACT

Hydro-meteorological hazards annually lead to considerable economic losses worldwide. Property level flood risk adaptation (PLFRA) measures have shown to decrease potential damages by floods and other hazards. However, such measures are often implemented inadequately, frequently because of lacking communication between public administration and homeowners. Thus, risk communication systems have been created by multiple actors, ranging from the government to private companies and insurance groups, which have the goal to communicate risks to homeowners and businesses in a tailored manner. Consequently, adaptive behaviour can be triggered by risk communication. This paper conducted a cross-comparison of several risk communication systems which encompassed an output in the shape of a label or guideline, based on semi-structured interviews with relevant experts. One system, the German *Hochwasserpass*, was focused on in more detail. The results show that risk communication systems should include participatory approaches with experts to trigger adaptive behaviour. However, even in an example including mutual knowledge transfer a gap between knowledge about mitigation measures and actually implementing them was present. Thus, this implies going a step beyond, which ultimately questions the resource efficiency of such risk communication systems on a larger scale.

1. Introduction

Communities affected by flood hazard events are characterised by complex interactions between human and water systems [1,2]. Risk communication is a way of transmitting complex information to people affected by flood hazards often with the aim to motivate adaptive behaviour in the form of property level flood risk adaptation (PLFRA) measures [3–5]. The measures range from dry flood-proofing (sealing building openings, etc.), wet flood-proofing (sump-pumps, etc.), avoidance of floods (floating buildings, etc.) to barrier systems (sandbags, etc.). Other measures include adapting building interiors, preparing emergency kits and understanding local emergency procedures (for detailed analyses see [6, 7–12]). The implementation of PLFRA measures and thus raising the self-responsibility of homeowners and businesses, has not only shown to reduce losses from natural hazards [13–17] but is also cost-efficient in combination with conventional structural protection [17,18]. Thus, this has the goal to raise the resilience of communities in the long run. Community resilience is understood as a settlement having the ability to absorb disturbances and learn, adapt or reorganise following an impact [19–21]. Within risk communication processes, especially the information on PLFRA measures is often communicated in diverse ways, one reason being that risk is perceived differently by experts and the broader public [22–26]. Hence, the communication of such information from experts to non-experts is in many circumstances inadequate [27], as information is often not received in the way it was delivered [13]. As discussed in several papers, simply providing information on hazards, risks and adaptation strategies in a one-way communication pathway[1] will most likely not be able to promote adaptive behaviour [4,29–33]. Thus, as analysed in recent literature risk communication, which is adjusted to specific needs of

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[1] One-way communication is information solely transferred from one direction to the other [28].

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people, can influence the perception on risk and encourage adaptive behaviour [34–39].

1.1. Risk communication and adaptive behaviour

The Sendai Framework for Disaster Risk Reduction (SFDRR) proposes to achieve people-centred risk communication mechanisms which include participatory processes and are tailored to the needs of users [40]. Höppner et al. [28] define risk communication as an approach to raise awareness, encourage adaptive behaviour, inform on hazards, risks and behaviours during an event, build trust, enable mutual dialogue and involve actors in decision-making [28]. According to Renn [41], the objectives of risk communication are: (1) enlightenment function – all receivers of the message can understand the content and thereby improve their knowledge about the risk communicated; (2) building confidence – create trust in the relationship between sender and receiver; (3) inducing risk reduction through communication – persuade the receivers to change their behaviour towards a specific risk, and lastly (4) cooperative decision making – all affected parties are included in the conflict-resolution process. These objectives need different types of communication, which can consequently be distinguished into four groups: (1) documentation – create transparency where it is secondary whether the information is understood by everyone; (2) information – communicate the material in a way that the meaning is understood by the receiver; (3) two-way communication/mutual dialogue – two-way learning including an exchange of experiences and arguments, and lastly (4) mutual decision-making and involvement – including people adequately (directly and/or indirectly) in decision-making processes. For risk communication to be effective, it would include all four types of communication listed as well as the four objectives mentioned earlier [41]. These categorisations by Renn [41] are partly based on earlier works by and Leiss [42], Löfstedt [43], Covello, et al. [44], Morgan, et al. [45]. Several recent studies build upon these approaches discussing different communication approaches concerning natural hazards (e.g. [46, 47, 48]). In line with the aim of this paper, a key goal of risk communication, is to motivate people at risk to realise PLFRA measures in light of possible impacts [49]. Considering the integrated model of risk communication by O'Neill [50], face-to-face learning phases are needed to benefit from local knowledge and engage individuals to act in a community. This interaction can encourage individuals to adapt to flood hazards. Nevertheless, it is difficult to define what 'good' risk communication is, as this depends on the actors involved and the goal aimed at [51]. Hence, for this paper 'good' risk communication will be defined as communication which encourages the public/receivers to implement PLFRA measures on the properties at risk. Flood risk communication can be improved by considering how the public perceives flood risk [52]. For example, 'self-efficacy' (perceived ability to implement PLFRA measures) is positively related to preparedness [38] and should be considered in risk communication strategies.

An important factor influencing the effectiveness of risk communication is trust [30,44,52–57]. Trust can be defined as "an expression of confidence between the parties in an exchange transaction and can be both process/system- or outcome-based" [43]. Trust entails the trustor (public/receivers) who places trust in the trustee (sending experts/other stakeholder groups). In the context of flood risk communication, the trustees can be the local government, neighbours, volunteers of emergency and relief service and relevant experts [56]. Also groups of community members, such as flood action groups, can motivate protective behaviour [58,59]. These flood action groups inform citizens on flood-related issues and PLFRA measures [58]. These community members are seen to be 'peer educators' or 'local champions', which can be trained volunteers that act in a face-to-face educational manner. Thereby, community learning is desired, which can lead to a more informed broader public [28,50,60]. Also, the receptiveness of homeowners is influenced by the trust they have in existing flood protection measures. Trust in public protection measures correlates negatively with preparedness at a household level [14,54,61]. A higher level of trust in large scale protection measures, can reduce a homeowners willingness to implement local adaptation strategies due to a false sense of security [52,62]. Additionally, flood-related negative emotions show to be positively associated with adaptive behaviour [63]. However, communicating fear and anxiety might have the counteractive result of desensitising the public to danger [64], or lead to denial of existing risk [50,51].

Moreover, the medium and mode of communication are of great importance concerning risk behaviour [31]. Communication can occur in written form (newspapers, reports, letters, etc.), verbally (conversations, lectures, etc.) and non-verbally (visually). In many cases, risk communication is operated by public authorities, which distribute information through brochures, various media channels, websites, web-GIS and guidelines [28]. Although received by many, these are only appreciated and comprehended by a small number of people and can thus be questioned in their effectiveness to communicate risks [27,34,65]. Previous studies on the content of flood risk maps conducted during the implementation of the EU Floods Directive (2007/60/EC) [66] have shown communication biases [24,67,68]. According to this EU Directive, flood hazard and risk maps do not have to include protection and mitigation measures on a household level. However, there are examples of risk communication which include such maps and additionally information on private adaptation measures, which in turn may be used for vulnerability reduction [17,69,70]. Globally, web-based, mobile communication technologies and social media such as Twitter, etc. are used to distribute information on hazards and risks before, during and after events [47,48,71–74]. The aim of these various risk communication systems and the outputs in the shape of labels or guidelines is to communicate tailored information on individual risk and possible PLFRA measures. The term 'tailored' is in this case used synonymously to 'custom-made' and thus means that information is individualised to the specific user. To establish relations between the communicating actors, at least two-way communication between experts and the public should be aimed at [32,75,76]. Essentially, the information should be tailored to the targeted audience [4,77] and a relation of trust should be established.

1.2. Objectives

The aim of this paper, is to analyse existing communication systems available in different countries and thereby gain an understanding about the state-of-the art. Especially systems which have the goal to communicate tailored information on flood hazards are looked into in further detail. Moreover, an example of a two-way communication pathway[2] within a German communication system called *Hochwasserpass* is discussed. Thus, the questions to be answered at the end of this paper are:

(1) Which online information systems concerned with tailored flood risk communication can be identified? Which characteristics are included?
(2) How can the risk communication systems enhance individual adaptive behaviour?

The remainder of the paper is organised as follows: Section 2. *Methods* provides an overview of the used methods, divided into the screening and selection of communication systems and the cross-comparison of these. Following this, the case study analysis of one particular risk communication system and its feasibility based on user experiences is described. Section 3. *Results* presents the results of the analysis and section 4. *Discussion and Conclusion* draws conclusions on

[2] Two-way communication can appear in a non-dialogical form (one actor consulting the other) and a dialogical form (through the mutual exchange of information) [28].

the link between risk communication and individual adaptive behaviour.

2. Methods

To answer the research questions, the research design includes a four-step qualitative research approach in which the selected risk communication systems and the process of one specific communication system are analysed. An overview of the four steps can be seen in Fig. 1.

2.1. Screening and selection of communication systems

Different risk communication systems were explored based on their online availability and emphasis on informing groups of people which do not have an expertise in flood risk such as homeowners, developers, enterprises, etc. All systems selected are online platforms, as we are specifically interested in the online availability of flood risk information and the varying communication approaches used in different countries. Additionally, all systems have an output in the form of a label or guide and thereby create tailored information for the user. These criteria helped to select systems which provide tailored information to their intended users. Moreover, the choice of the analysed systems was based on the language proficiencies of the authors (English, German and Dutch). Keywords used for the online search of the tools included: flood; label; property; risk communication; tool; app; mitigation; adaptation; hazard. Also newspaper articles and other popular scientific contributions were additionally used for finding communication systems. Nine information systems were chosen for a detailed analysis. These systems included: (1) the Netherlands – *Overstroomik.nl*, (2) Belgium – *Watertoets*, (3) the UK – *Flood Toolkit* and (4) *Know Your Flood Risk*, (5) the USA – *Beyond Floods*^{TM} and *(6) Coastal Risk Consulting*, (7) Switzerland – *Schutz vor Naturgefahren,* (8) Canada – *Aviva, Plan & Protect*, and (9) Germany – *Hochwasserpass.* Semi-structured interviews with the relevant developers and experts involved in the process of creating the systems were conducted either personally, via e-mail, by telephone or skype. During the semi-structured interviews, information on the background and development of the systems was gathered based on the pillars of risk communication by Höppner et al. [28] (actors, purposes, modes, tools and messages) and the objectives of risk communication by Renn [41] (documentation, information, two-way communication/mutual dialogue, mutual decision-making and involvement). Thus, the interview questions included topics on (1) the developing organisation of the system, (2) the purpose of the system, (3) the information required to run the system, (4) the output of the system (content of the system), (5) the cost of the output for the user, (6) the usability for experts and (7) whether the system was based on preferences of potential users.

2.2. Cross-comparison of communication systems

Using the information acquired during the semi-structured interviews an overview of the systems was made. Consequently, a cross-comparison of the systems was prepared on basis of the analysed risk communication literature. Hereby, the information gained on the systems was analysed and new categories of analysis created: (1) the purpose of the system (inform homeowners, businesses, developers, etc. or is it a decision making tool for experts), (2) the information pathway of the system (one-way: in the shape of a website, two-way: the presence of technical advice by an expert on site), (2) the content of the system (the presence of a tailored hazard/risk map by using a postcode, information on PLFRA measures, information on contacts to risk engineers and insurances, information on evacuation plans and whether there is a risk label for a property), (3) the user-centred information (whether the online information and/or output is free of charge, whether the label is free of charge, whether there is an additional login or information source on an expert level, if users gain subsidies by using the system and whether the system is established based on potential users). The reason for analysing the different systems based on the chosen categories, was to create an understanding of the similarities and differences of existing communication systems and thus of the state-of-the-art. The analysis of the systems did not have the goal to decide which system was 'better' than the other, as a rating as such is not possible without extensive and detailed user feedbacks (which are in most cases not available).

2.3. Selection of case study

Concentrating on one specific information system and the effect on the risk behaviour of users, the German *Hochwasserpass*, was analysed. This system provides users with a flood risk label of their property after a

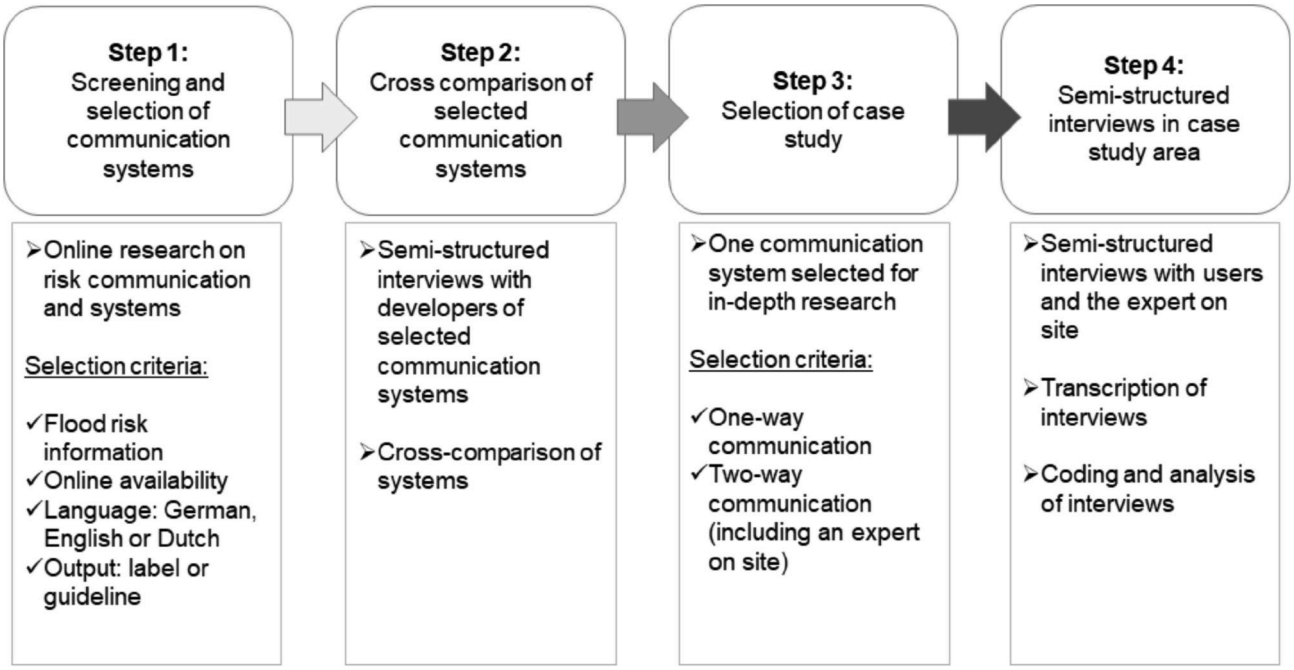

Fig. 1. Overview of methods used.

thorough analysis of the property construction and location in relation to various types of flooding. The flood risk labels can be compared to the EU Energy label, which has the goal to rate the energy efficiency of a building or electric devices [78]. The reason for the in-depth analysis of this system was that the information pathway includes a one-way information source and a two-way communication pathway. The two-way pathway encompasses an expert visit on-site, who provides tailored information for the property at risk. Hereby, the goal is to understand whether mutual knowledge transfer through two-way communication between an expert and receiver (homeowner/enterprise) encourages adaptive behaviour.

The in-depth analysis of the *Hochwasserpass* took place in Neuburg an der Donau (29 608 inhabitants), a city along the Danube River in Southern Germany in April 2018. Significant flood events occurred mid May 1999 and in the years 2002, 2005 and 2013 [79–81]. The flood event of 1999 became one of the largest inundations of the last 100 years in Southern Germany [81]. Approximately 100 000 people were affected by the floods and 5 people lost their lives. Roughly 100 people had to be evacuated and the damages encompassed about 657 million Deutsche Mark (DM) (roughly 336 million Euros). Unusually high peak discharges caused dyke failures and thus large inundations surrounding the area of Ingolstadt and Neuburg an der Donau [81]. Following this flood event, several public protection measures were implemented. These included dykes and flood walls, mobile flood barrier systems and relocation of properties which could not be guaranteed an acceptable level of protection [82]. Due to stream regulations of the Danube river in the 19th and 20th century, the river has lost its natural dynamics. Therefore, another measure which influences the flood risk management of the area is the enhancement of the Danube floodplain through controlled ecological flooding [83]. Hence, Neuburg an der Donau was chosen as a case study location, due to the inhabitants' experiences with flood events over the past decades. Flood sources vary from pluvial to fluvial and the risk awareness among residents is expected to be high. It is therefore an interesting setting where the experience of flood has become part of collective knowledge.

2.4. Semi-structured interviews in case study area

Semi-structured interviews were conducted in German with homeowners and small enterprises that participated in the *Hochwasserpass* process by the HKC (German Centre for Flood Knowledge and Action) in Neuburg an der Donau. In total, these were eight participants consisting of four privately owned properties and four company buildings. The reason for the choice of these participants was that they obtained expert advice by the same expert and participated in the study by the HKC. The interview guide included questions based on the objectives of risk communication as stated by Renn [41] (enlightenment function, building confidence, inducing risk reduction and cooperative decision making) and factors influencing risk behaviour: (1) the flood experience, (2) the reason to participate in the *Hochwasserpass* process (thus the motivation to receive tailored information), (3) contact to neighbours (peer educators), (4) whether the process of the *Hochwasserpass* was based on mutual knowledge transfer, (5) the self-efficacy and motivation to implement PLFRA measures and (6) the impact on the emotions related to future flood event (feeling of safety) resulting from the process of the *Hochwasserpass*. Additionally, the expert who generated the *Hochwasserpass* was interviewed to understand the process applied. All interviews were analysed using the software f4transkript and f4analyse. This included the process of coding the transcribed interviews and identifying relevant themes, by considering qualitative research methods as seen in Corbin & Strauss [84] and Saldaña [85].

3. Results

The results of the research provided insights into different risk communication systems including information on the developers and their background. Through this gained knowledge, one communication system and the interaction with users could be analysed in more detail. These results will be discussed in the following sections.

3.1. Cross-comparison of communication systems

Using the semi-structured interviews with the respective developers, the communication systems were analysed based on different categories, displayed in Table 1. To comprehensively compare the different communication systems, these categories were analysed based on their affiliations (governmental, corporate systems/insurance-led and collaborative approaches: NGOs, research institutes, insurance companies). All communication systems have different backgrounds, developers and outputs, although the systems have a common aim, that is to inform users about their risk level in a tailored manner. The in-depth analysis of the systems gave insights into which system should be analysed further to understand the effect on adaptive behaviour.

3.1.1. Governmental systems

Systems from the Netherlands (*Overstroomik.nl*), Belgium (*Watertoets*) and one from the UK (*Flood Toolkit*) were developed and are now maintained by governmental organisations. The Dutch and UK systems are online platforms aiming at informing the public in a one-way manner by also using flood risk maps. However, they focus on slightly different groups within the public audience. *Overstroomik.nl* aims at informing citizens about their individual flood risk and the possible options during emergency situations when staying or leaving. *Flood Toolkit* informs users of their risk by using flood risk maps and provides general information on adaptation for homeowners, planners, land owners and property developers. *Watertoets* does not aim at informing users, but serves as a decision-making process for permits and planning in combination with the possibility of including an expert on site who evaluates the local flood risks if wanted by the user. Thus, in that case, face-to-face interaction is voluntary. *Watertoets* is a more expert-oriented system and is designed to be used by experts involved in planning-related decision-making processes.

3.1.2. Corporate systems/Insurance-led

Another set of communication systems is developed and maintained by private companies. The second UK system in this analysis *Know Your Flood Risk* is run by a private company. It aims at informing homeowners and property developers about different flood risks by motivating the user to buy a flood report. This report is generated through the company by analysing flood data for the requested location. Additionally, both systems *Beyond Floods*^{TM} and *Coastal Risk Consulting* developed in the USA are corporately run. *Beyond Floods*^{TM} aims to inform homeowners and sell a risk label. *Coastal Risk Consulting* aims at a broader set of users, namely homeowners, businesses and the government. The system also sells reports and consequently a label on the individual risk level, generated using flood related data on coastal flooding. All corporate systems aim at informing users by selling reports or labels which indicate the buyers' individual flood risk. The Swiss system *Schutz vor Naturgefahren* is a website developed by an insurance company with very detailed information on PLFRA measures. It informs homeowners, architects and property developers on how to protect their property from several types of hazards. The output is for free, thus the website does not aim at selling a label. Additionally, there is no face-to-face interaction with an expert on site.

3.1.3. Collaborative systems: NGOs, research institutes, insurance companies

The third category of systems are developed collaboratively. The *Hochwasserpass* is being developed by the HKC, a network NGO, with support from the German Association of Insurers. It aims at informing and providing solutions for homeowners and small businesses by creating a label for the property at risk by having an expert inspect the

Table 1
Overview of categories related to the risk communication systems based on the results of the interviews and analysis (+: included in the system, +/−: partly included in the system, -: not included in the system, o: information not available).

		Information Systems and Developers								
		Overstroomik.nl (The Netherlands)	Watertoets (Belgium)	Flood Toolkit (UK)	Know Your Flood Risk (UK)	Beyond Floods™ (USA)	Coastal Risk Consulting (USA)	Schutz vor Naturgefahren (Switzerland)	Aviva Plan & Protect (Canada)	Hochwasser- pass (Germany)
Categories of Analysis		Government	Government	Government	Private company	Private company	Private company	Insurance company	Insurance company + Research institute	NGO
Purpose of the system	Information for homeowners, businesses, developers, etc.	+	+	+	+	+	+	+	+	+
	Decision-making tool for expert	–	+	–	–	–	–	+	–	+
Information pathway	One-way (website)	+	+	+	+	+	+	+	+	+
	Two-way (technical advice by expert on site)	–	+	–	–	–	–	–	–	+
Content	Tailored risk/hazard map (search for postcode)	+	+	+	+	+	+	–	–	–
	Information on PLFRA measures	+	+	+	+	+	–	+	+	+
	Information on contacts to engineers, insurances, other risk transfer systems, etc.	+	+	+	+	+	+	+	+	+
	Risk 'label' for a property	–	–	–	+	+	+	–	–	+
User centred information	Online output (guideline or information) is free of charge	+	+	+	+	+	+	+	+	+
	Label is free of charge	o	o	o	–	–	–	o	o	–
	Additional information/login for experts/engineers	–	+	–	–	–	–	+	–	+
	Users gain subsidies by using the system	–	–	–	–	o	o	–	–	–
	System is based on potential users	+	–	+	+	o	o	o	o	+/–

property on site. *Aviva – Plan & Protect* however, serves as an emergency information system in Canada. It was created by an insurance group in collaboration with a research institute. The system provides offline information about what to do before, during and after hazard events and provides further information on insurance possibilities concerning natural hazards. Most other communication systems analysed do not provide emergency information (except *Overstroomik.nl*) making *Aviva – Plan & Protect* a slightly different approach.

3.2. Results from the Hochwasserpass analysis

Considering the different communication systems analysed, two go beyond the idea of informing homeowners and property developers in a one-way communication pathway (*Watertoets* and *Hochwasserpass*). The two-way communication part in both systems consists of experts/engineers personally visiting the sites to be analysed and giving recommendations on PLFRA measures. This generates a personal interaction between homeowner/enterprise and expert. The *Hochwasserpass* includes a more extensive one-way communication with wide-ranging information on floods and mitigation measures online, than the *Watertoets*. Considering the communication modes which are to be analysed (one-way and two-way), the *Hochwasserpass* includes more input for public users and thus provides more far-reaching substance for this analysis. Within the *Hochwasserpass*, the experts provide an output in the shape of a label for buildings on a scale from red to green, depending on the exposure, past events and already existing PLFRA measures for four types of flooding – river floods, pluvial floods, groundwater flooding, and backwater from sewage systems. Thus, the *Hochwasserpass* was examined further based on semi-structured interviews with individuals participating in the evaluation process by the HKC. The participants were contacted by the expert leading the *Hochwasserpass* process in the community. After their approval to participate, the expert conducted a preceding analysis of the property at risk. Consequently, the expert visited the properties of the participants in order to complete the process of the *Hochwasserpass* together with the participants. The mentioned participants of the *Hochwasserpass* process are the interviewees within this analysis. The results from the semi-structured interviews in Neuburg an der Donau are summarised in Table 2.

3.2.1. Motivation to participate in the Hochwasserpass

The spring flood event of 1999 played an important role in the engagement with the *Hochwasserpass*. This flood event caused damages of various extents on all properties involved in the *Hochwasserpass* process, both private and for small enterprises, of which specifically flooded basements were mentioned. The participants took part in the *Hochwasserpass* process based on several motives, ranging from the anxiety of facing new damages and related clean-up costs by future flood events to the personal connection to the expert giving advice on site. The latter reason was highlighted by every interviewee and was thus the main motivation to participate in the *Hochwasserpass*. Interviewees emphasised that the experts' knowledge was considered to be of a trustworthy source in order to complete the *Hochwasserpass* correctly:

> *"He [the expert] is very experienced, because he has extensive work experience in this area. I wouldn't trust someone else to give me correct information, if it's not a special company. And even then I would always think, they just want to earn money … ((laughs))." (Interview 4 - Private)*

It is very prominent that the personal connection to the information source (in this case the expert) is of great importance to most interviewees. Additionally, the interviewees appreciated the mutual knowledge transfer with the expert. They had the possibility to explain their situation and ideas about possible PLFRA measures during the process of the expert visit. Those ideas were considered for the final assessment of the label:

Table 2
Summary of semi-structured interviews divided into participants 'private households' and 'enterprise'.

Categories of analysis	Private	Enterprise
Flood experience	• Spring flood event 1999	• Spring flood event 1999
Damages by flood events	• Flooded basements, mud	• Flooded basements
Motives to join the *Hochwasserpass*	• Personal/professional connection to the expert • Information about prevalent risk	• Personal/professional connection to the expert
Contact people during the *Hochwasserpass* process	• Only the expert	• The expert • In a few cases the city
Exchange with neighbours	• No discussion with neighbours	• Some interaction with neighbouring companies
Process of the *Hochwasserpass* (opinions)	• Positive, due to high trust in the expert • Lenient attitude towards a few mistakes made by the expert in terms of speed	• Positive, due to high trust in the expert
Knowledge transfer	• Mutual (participants were able to ask questions and add further information in the process)	• Mutual (less interaction; usually one meeting in which important topics were discussed)
Self-efficacy	• Little knowledge on how to find PLFRA measures and who to contact • Use of website: Very few used the website • Implementation of PLFRA measures: check-valves, sealing building openings, adapted building use, waterproof cellar, flood proof basement windows, elevated light shafts	• Little knowledge on how to find PLFRA measures and who to contact • Use of website: Website was only used during the meeting with the expert • Implementation of PLFRA measures: Adapted building use (large scale), temporary barriers (sandbags-), sealing building openings, check-valves, sump pumps
Understanding of *Hochwasserpass* results	• Little knowledge about the meaning of the results	• Large knowledge about the meaning of the results
Willingness to pay an expert	• Low willingness to pay an expert	• Low willingness to pay an expert
General feeling of safety after *Hochwasserpass* process	• Lower than before	• Lower than before

> *"Yes, we [the expert and the interviewee] did a lot together, as he [the expert] knows our building operations very well due to his responsibilities in the field of flood protection. We went over everything we did, especially the measures." (Interview 7 - Enterprise)*

The use of the website of the *Hochwasserpass* and the information communicated through it was secondary to the participants and had little effect on their motivation to take part in the *Hochwasserpass* process or implement PLFRA measures. Nevertheless, the interviewees consider the label which is acquired after the expert input on site, as an instrument to raise awareness:

> *"Well, it [the Hochwasserpass] did do some good … At least, it raised the [flood] awareness again." (Interview 1 - Private)*

The visit and analysis conducted during the *Hochwasserpass* process was subsidised, meaning labels were free of charge for the participants. Considering this subsidy, no interviewee would want to pay high amounts for the *Hochwasserpass* process:

> *"Let's put it that way, for me personally this [the Hochwasserpass] is only worth a few hundred Euros …. I see the effort behind it. So there should*

really be a way, that somebody supports this … To find a subsidy from somewhere." (Interview 1 - Private)

3.2.2. Self-efficacy

The majority of participants implemented PLFRA measures, varying in size and technical sophistication. The small enterprises implemented similar measures on a larger scale. Nevertheless, there were still exceptions where no adaptation measures were implemented. The expert provided the residents and enterprises with information on PLFRA measures for their specific flood risks. However, after the experts visit some of the interviewees did not know who, as in which engineer or company to contact to help implement or buy the measures, even though this information is provided on the *Hochwasserpass* website. Some interviewees had family members or acquaintances who were technically educated, whereas others were still trying to find addresses and contacts for help. This knowledge gap lead to several interviewees losing their motivation to implement PLFRA measures:

"Where to get the information and where to get the measures, which should be implemented … where do you go and who do you ask." (Interview 4 - Private)

3.2.3. General feeling of security

The experience of a flood event can have a negative effect on a persons' feeling of safety. For a system like the *Hochwasserpass* it is important to tap into the experience of floods to motivate people, although there is a fine line between building on that experience and raising feelings of anxiety. Most interviewees considered the label as a checklist. Although this might sound motivating, it created anxiety regarding possible damages by future floods if not completed. Thus, this checklist acted as a motivator to implement measures and thereby decrease items listed by the expert, consequently working towards a safer property. It is noteworthy that interviewees emphasised they did not experience an increase in feeling safety after the process of the *Hochwasserpass*. On the contrary, participants essentially felt less safe after knowing more about their level of risk and the possible consequences of a future event. It is not the intention of *Hochwasserpass* process to make the interviewees feel less safe. However, this case study points to a relation between negative flood-related emotions and fear as a motivator to implement measures:

"I don't think that you feel safe by the Hochwasserpass or by a checklist as this one … I will only feel more protected if I can reduce this checklist. Now we are here [pointing at the measures to implement], and in five years we will reduce the 15 to dos by three or four points. Then I will think it was worth it." (Interview 7 - Enterprise)

4. Discussion and Conclusion

Considering the cross-comparison of the different communication systems, a common aspect within these systems is to communicate tailored information on risks. In many cases, the private companies sell individualised flood risk information, whereas public communication systems that focus on one-way communication are free of charge and the information given rather broad. Nevertheless, several systems use risk/hazard maps to communicate tailored information on specific postcodes. Only two of the systems analysed comprise the possibility of expert advice on site. In the case of the *Watertoets* this advice was voluntary, whereas in the case of the *Hochwasserpass,* it was part of the entire communication process. Only the *Hochwasserpass* included a two-way communication pathway in combination with an extensive one-way section which is made for the public. The *Hochwasserpass* process was evaluated and insights in the interviewees flood experience, motivations to implement PLFRA measures and sense of security were obtained.

Coherent with past and recent studies on risk communication, this paper clearly demonstrates that trust in the information source is a vital building block for successful risk communication methods [30,52–58]. The expert as an information source should not only be a flood hazard expert, but also a community member which is known to the people. Thus, this member has a high level of knowledge about the community structure. This was particularly present in Neuburg an der Donau, where the expert was a respected member of the community as well as an expert in flood hazard topics. It was especially apparent that the trust in the expert included that he/she does not draw any extra personal profit giving technical advice [57]. Consequently, flood risk communication systems can motivate adaptive behaviour under certain conditions: There needs to be a personal connection to the sender (the expert or authority that advises) and a two-way communication pathway which includes a mutual knowledge transfer from and to sender and receiver. As seen in O'Neill [50], by fostering face-to-face interactions, learning can be enhanced. This in turn might lead to collaborative problem-solving.

Although the personal advice of the expert was trustworthy, results showed low levels of security after the process of the *Hochwasserpass*. Thus the question arises whether this effect could implicate the success of the communication system in the future. Demeritt & Norbert [51] discuss that flood risk communication strategies which aim to motivate adaptation measures can have counteractive results, meaning that people respond through denial and consequently do not implement measures. On the contrary, other studies showed that negative feelings associated to floods had a positive relationship with adaptive behaviour [63]. Also, interviewees considered the checklist motivating to implement PLFRA measures and thereby raise the feeling of security.

Considering the *Hochwasserpass*, the motivation to have an interaction with the expert was larger than solely using the one-way source of information in the shape of a website. The type of communication used essentially goes beyond two-way communication and can be defined as mutual decision-making and involvement [28,41,86]. However, there is still a gap observed between having knowledge on PLFRA measures and actually implementing them [87–90]. As some participants of the *Hochwasserpass* process experienced low self-efficacy, the question arises whether the prevalent risk communication applied during the process of the *Hochwasserpass* is sufficient or whether the frequency of advice has to be increased. By increasing the frequency of advice, the result would be a second participatory pathway, in which the interviewees and the expert interact once more (see Fig. 2, "Step 3"). The expert would have to make sure that PLFRA measures are implemented or that there is a solid understanding on where to find these. Generally, two-way communication pathways and mutual decision-making processes confine the extent to which a wider community can be reached as the willingness to participate in face-to-face activities is limited [4,91,92]. If the frequency and scope of advice were to be increased in the *Hochwasserpass,* the effectiveness and resource efficiency on a larger scale, has to be questioned. An example of this process can be seen in Fig. 2.

Reflecting on the research design of this article, the study comprises certain limitations, which should be taken into account for future research. A larger number of communication systems could be considered for the cross-comparison to decrease the degree of bias. Additionally, it is not known, how many users have implemented measures after using these communication systems. This would require a broad and longitudinal study and could contribute to increase the scope of the study. Reflecting on the case study in Germany, it has to be considered that it is a very specific example and that the extent to which *Hochwasserpass*-labels have been tested, is still limited. Also, the expert being known to the participants might have created certain biases concerning the trustworthiness of the communication source. Thus, for further research, a broader understanding on similar case studies would be important to understand to what extent such communication systems can or cannot function. Therefore, longitudinal studies, which analyse the effect of participatory methods of risk communication on flood risk behaviour and preparedness would be constructive to extend the results

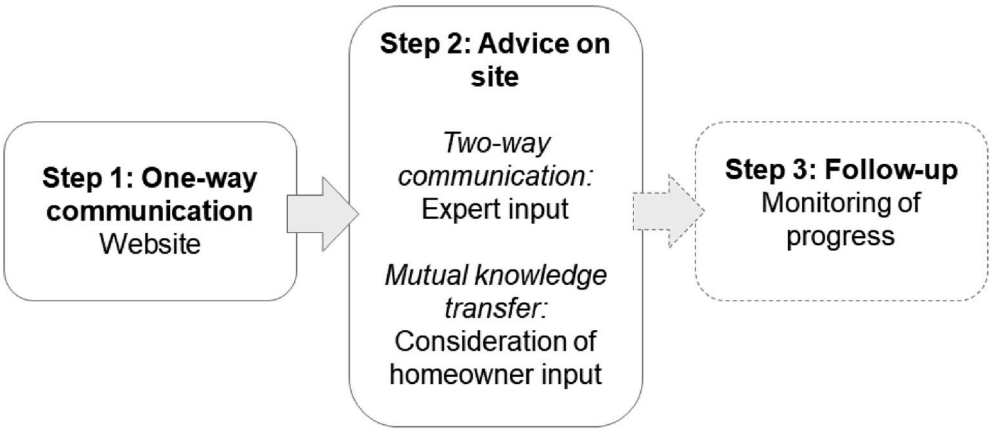

Fig. 2. Process of the *Hochwasserpass* (solid lines: existing steps; dotted outlines: potential third step of the process).

of this analysis. This could include an analysis of residents who have not acquired a *Hochwasserpass* and their reasons not to do so. Thereby, an understanding of which communication pathway is necessary and whether trust in the expert is always needed for motivating adaptive behaviour, could be made. This would create an understanding on the effectiveness of going beyond mutual knowledge transfer in communication processes, by monitoring peoples progress', on a larger scale and ultimately clarify whether examples such as the *Hochwasserpass* lead to greater individual resilience.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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