Local knowledge as key factor for implementing nature-based solutions for flood risk mitigation

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A tension between a scientific «expert» knowledge and a «traditional» local knowledge has always crossed Disaster Risk Reduction policies and practices. Big detention basins or large engineering works are usually preferred by delegated agencies for flood risk mitigation measures based on scientific hydraulic models. Due to economic or geo-morphological reasons these solutions can't be always implemented, and so challenging «traditional» cost-benefit analysis. This was the case of a six-year project called Rural Sustainable Drainage System (RSUDS), led since 2014 by the local government of Stroud, a village in South West England. Following the 2007 major floods occurred in England, four action groups were formed in the study site to demand for further flood risk mitigation measures. Due to the inefficiency of the engineering solutions proposed, which consisted of two large ponds working as detention basins, the bottom-up process resulted in the implementation of nature-based solutions consisting also of dozens of different small ponds with different functions to prevent from flooding. The different actors were bearers of different kind of knowledges, which interacted at local level, driven by relationships between actors and between actors and water catchments. Situated relationships and practices activated and produced local knowledges, due to the role of water flowing in shaping risk and risk framing. In terms of lesson learned, this case study showed how considering local knowledge in flood risk framing and management can refer to the multiple functions of nature-based solutions and be a threshold for effectiveness.

Keywords: nature-based solutions, local knowledge, flood risk mitigation, Rural Sustainable Drainage System, Stroud, risk governance.

1 Introduction

In the last decade, there has been a growing interest in the role of knowledge in disaster risk reduction: in *Disaster Studies*, in the public debate following major events, and in International *Disaster Risk Reduction* (DRR) policies (e.g. the 2005 *Hyogo Framework* and the 2015 *Sendai Framework*). «Local knowledge» has been often brought into the debate as a way to use knowledge in a more effective way (Shaw et al. 2009; Gaillard, Mercer 2012; McEwen, Jones 2012; Hiwasaki et al. 2014), while usually underestimated, misinterpreted or little acknowledged. From the policy level, the 2007 EU Floods Directive theoretically built a common European framework for flood risk management, providing a common flood risk governance perspective, which can give the opportunity to include different knowledges and actors into Disaster Risk Reduction policies and practices across Europe (Krieger 2013; Alexander et al. 2016). Within this convergence, flood risk works as a relevant research object to explore because it is often deemed by environmental scientist as a «known risk», but paradoxically floods are the most frequently experienced disasters in Europe (Barredo 2009). Both academic literature and International and National policies and reports have pointed out the need to engage with local actors and to acknowledge for local knowledges in risk management (Mercer et al. 2010; Gaillard, Mercer 2012; UNISDR 2005; 2015).

The research problem addressed in this paper is to outline how to include these knowledges into flood risk governance-based processes (Mercer et al. 2010; McEwen, Jones 2012; Weichselgartner, Pigeon 2015). With the concept of risk governance we mean «the various ways in which many actors, individuals and institutions, public and private, deal with risk surrounded by uncertainty, complexity and/or ambiguity. It includes formal institutions and regimes and informal arrangements. It refers to the totality of actors, rules, conventions, processes, and mechanisms concerned with how relevant risk information is collected, analysed, and communicated, and how regulatory decisions are taken» (Renn et al. 2011, 234). Some innovative practices, recently defined in EU policies as *nature-based solutions* or sometimes acknowledged as *natural flood management* (for a differentiation see Short et al. 2019) can provide suitable case studies to look at how different kind of knowledges can interact in tackling a paradigmatic type of risk, such as flood risk, within a risk governance framework. Indeed, *natural flood management* (NFM) works with natural processes to enhance socio-cultural processes for flood risk reduction with water and land management processes at catchment scale (SEPA 2015; Waylen et al. 2017; Short et al. 2019). The aim of this paper[1] is to show how the inclusion of local knowledge in flood risk management can be a threshold

[1] This paper stems from a 3-years PhD project (*Slowing down the flood, naturally. The integration of local knowledges into flood risk governance. Insights from South-West England and North Italy*), where two flood risk management projects in two different case studies were compared to understand how local knowledges

for DRR effectiveness both at societal (risk-related) and natural (hazard-related) level (Short et al. 2019). A bottom-up process of nature-based solutions' implementation in the UK (called Rural Sustainable Drainage System RSUDS) will provide a case study to explore this issue. This case study, based on the Stroud District in the Cotswolds (Gloucestershire County), can be considered highly representative for our aim. Indeed, the concept of «local knowledge» was explicitly mentioned in reports and academic papers debating the 2007 floods, one the worst floods ever reported in the UK. During the wettest summer ever recorded (414.1mm), on June 24th/25th and July 20th/21st heavy rain hit Yorkshire, Derbyshire, Lincolnshire, Nottinghamshire and Worcestershire, South West England and South East parts of Wales. Three were found dead and around 56,000 properties were flooded, according to the Environment Agency, the Government's Statutory Agency with regard to flooding. Gloucestershire was severely affected, with 5,000 property flooded (80% hit by flash floods) and 1,950 people assisted in temporary housings, 500 business affected and around 140,000 homes remained without water supplies for up to 17 days. Haughton et al. (2015) noted how post-flood reports highlighted that «the impact of flooding was exacerbated by the loss of engineers on the ground with high levels of relevant local knowledge and experience» (Haughton et al. 2015, 375).

2 Local knowledge in Disaster Risk Reduction

Spiekermann et al. (2015) suggest we need to look deeper at how knowledge implementation in DRR can be improved, instead of focusing on research-based knowledge. The issue of implementing and converting knowledge into effective applications lies at the core of the problem. Likewise, the issue of the inadequacy of science in dealing with contemporary risks has been pointed out by different scholars (De Marchi 2008; 2015; Funtowicz, Ravetz 1992), resulting in the need to integrate different kinds of knowledges in inclusive ways in addressing risk and environmental policies: from Renn's risk governance framework (Renn 2008), up to the concept of «post-normal science» or the awareness that science has been always informed by what had been defined as «folk knowledge» (Sillitoe 2007). Since the reflexive modernization theory (Beck 1986), the expert/lay divide has been addressed with different perspectives also linked to environmental issues. According to Pellizzoni (1999), we can distinguish four different epistemological perspectives, from the cognitivist perspective of the sociologists Beck and Giddens to the more hermeneutic and social constructionist one of Wynne (1996) and Funtowicz and Ravetz (1992). Power and political

can be integrated into natural flood management processes within a flood risk governance framework. The fieldwork was undertaken by the corresponding author.

issues linked to the production, use and transmission of expert knowledge, mostly driven by a supposed epistemological legitimacy of scientific knowledge have been also widely discussed and acknowledged (Funtowicz, Ravetz 1992; Pellizzoni 1999; De Marchi et al. 2001; Sillitoe 2007; De Marchi 2015). The use of the concept of local knowledge and its cognate notions in Environmental and Development studies (Blaikie et al. 1997; Sillitoe 2007) has shown how this tension can be addressed by looking at situated relationships and interactions that shape knowledges at local level, combining expert, «traditional», implicit, social and holistic knowledges.

Following a social constructionist approach, the point from our perspective is how to identify, engage with, evaluate and apply these knowledges at local level in flood risk management processes. Natural flood management processes, as they are catchment-based, can provide excellent case studies to unpack the concept of local knowledge and analyse how it works within a flood risk governance framework. Indeed, in the field of Disaster Studies, following the risk theory by Boholm and Corvellec (2011), it is possible to define the source of a possible harm as a «risk object», meaning with «object» everything that «pose hazards», being an activity, a law, a thing, an entity, a human being. The point, given a «situated» risk governance, is to explore the ways in which «people construct and develop meaningful networks of causally linked risk objects» (ibidem, 177), which construct local knowledges. Therefore, risk sources are not objective, «out there», rather they are designated as risky through a social act embedded in a network of practices, discourses and representations. The putative harm can be defined as the «object at risk». Furthermore, the act itself of designating an object at risk (through practices, discourses, representations) is an act implicating a value, «validating something» (ibidem). Therefore, as Boholm and Corvellec suggest, «risk management and governance strive to keep the risk object out and the object at risk in by developing an adequate risk management regime» (ibidem, 180). So, object at risk are emplaced and displaced in different relationships/interactions working as chains of causation in diverse ways «as probabilities, models, laboratory tests, narratives, or else» (ibidem).

In parallel, a «local knowledge» issue has been raised at policy level (Hiwasaki et al. 2014). The need to exchange knowledges between practitioners and stakeholders has been constantly evoked in UN International DRR policies since the 1980s (UNISDR 2005). A people-centred approach, partially accounting for the most vulnerable groups apparently drove the Sendai Framework for Disaster Risk Reduction, the report adopted at the Third UN World Conference on Disaster Risk Reduction in 2015, whose targets should be achieved by 2030. Despite the effectiveness of its targets and the absence of detailed measures for tackling the most vulnerable groups (Forino 2015), one of the Implementing nature-based solutions for flood risk mitigation 385 priorities turned into the strengthening of disaster governance by acting in every phase of the «disaster cycle» and

including the participation of relevant stakeholders to «ensure the use of traditional, indigenous and local knowledge and practices, as appropriate, to complement scientific knowledge in disaster risk assessment and the development and implementation of policies» (UNISDR 2015, 11).

Alternatively, there is still no agreement in Disaster Studies on what local knowledge is and how it can be defined. Moreover, different terms (Ellen, Harris 2000) have been used to refer to potentially overlapping or different local ways/knowledges/practices in tackling risk and/or adapting to a specific environment. In the field of DRR, Mercer refers to local knowledge as a form of «inside knowledge», «acquired by local people over a period of time through accumulation of experiences, society-nature relationships, community practices and institutions, and through passing it down through generations» (Mercer 2012, 99). This is contraposed to «outside knowledge», an explicit knowledge typically Western and scientific-based, universally applicable. Inside knowledge is also linked to the concept of tacit knowledge, a knowledge which is «not necessarily articulated in written or verbal forms but it is implicit in the actions and practices of individuals or group» (Mercer 2012, 98), as a part of daily life. What emerges from Mercer's perspective is still the need to integrate the two forms of knowledge into a hybrid one, combining and making accessible, tangible, applicable, appropriate and context-specific the result of this combination (Mercer 2012). This hybrid knowledge, mixing expert, scientific and local knowledge in discourses, policies, practices and projects at local level is what this paper means by the concept of local knowledge.

Following Wisner (2009), Haughton et al. (2015) and Mercer (2012), we should put situated relationships at the centre of DRR policies and practices, considering them as a combination of physical and socio-cultural characteristics to be dealt at the same time by different actors with different perspectives. This has the potential to turn local knowledge into something that «comprises the totality of perceptions, beliefs, understandings, and skills that one or more members of a community use or potentially use to communicate about and manipulate the world» (Wisner 2009, 1). In this sense, local knowledge can be referred as «local knowledges» and is essentially social, resulting from a relation, and not entirely «traditional»: «It can incorporate part/ version of outside/scientific knowledge», being not static and tending to mix and hybridise. It may not be «explicitly spoken about those who have it. It is sometimes tacit or implicit in their practices and acts» (Wisner 2009, 3). In our opinion, the notion proposed by Wisner overcomes some issues emerged in the literature: the stereotyped notion of indigenous/local knowledge, being something static, traditional, orally transmitted, uniformly owned by a fixed community, irrational and opposed to scientific knowledge. Following a social constructionist approach, the «binary tension» can be sorted by acknowledging the different components and sources through which this kind of knowledge is built upon (produced, identified, transmitted and used) at the local level. Situated

practices, knowledge sharing and hybridization, daily prolonged interactions and implicit meanings need to be explored to unpack the concept, so that, «risk reduction will have to be carried out at the end of the day by people in places» (Wisner 2009, 5).

3 Case Study

The study site addressed in our research is located in Stroud, a market town with around 30,000 inhabitants (112,779 in the whole District in 2018) in Gloucestershire, South West England (fig. 1). In geographical terms, the Stroud area is a protected lowland landscape of permanent pasture and broadleaved woodland in steep valleys and arable and pasture on upper plateau. Climate change is expected to increase the winter precipitation and result in more extreme events.

The River Frome flows in this area and its catchment covers 260km², and flows directly into the lower reaches of the River Severn. For centuries, the Frome catchment has been used for drinking water, agricultural and industrial purposes, which has inevitably resulted in numerous modifications to manipulate and control flow. The Lower Frome through the market towns of Stroud and Stonehouse remains heavily industrialised and there is increasing and ongoing residential development of former industrial sites and mill buildings. There are also many complex interactions between the Frome, its tributaries, springs and the Stroudwater Canal. In the Stroud area from steep calcareous valley upstream, run-off and tributaries flow downstream through urban areas, with some culverted stretches.

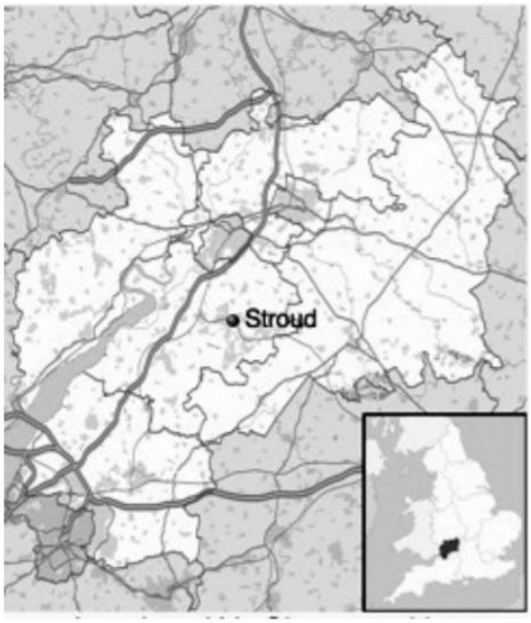

Figure 1 Stroud in Gloucestershire County (left) and location of Gloucestershire in the United Kingdom (Contains Ordnance Survey data © Crown copyright and database right, CC BY-SA 3.0).

This area was badly affected by the 2007 floods: in July 2007 the Upper Frome, Painswick Stream and Slad Brook (tributaries) flooded, over 200 properties in Stroud were affected. Summer flooding, as in 2007, was also recorded in July 1907 and August 1931; the two largest historic flood events on record occurred in 1965 and 1968 where a large number of properties along the Frome valley were flooded. The most widespread flooding occurs after sustained periods of rainfall, subsequent increased groundwater levels/flow causing increased base-flow combined with increased runoff response from land areas.

Following the 2007 major flood, a three-year project called Rural Sustainable Drainage System (RSUDS), led by the local government, Stroud District Council (SDC) was established in 2014. A full-time project officer was appointed in May 2014 along with Regional funding to promote Natural Flood Management works, this scheme was then extended to March 2020.

3.1 Flood risk management in the study site

From the policy level, the 2007 EU Floods Directive (FD) theoretically built a common European scenario for flood risk management, providing a shared flood risk governance perspective (EP 2007). This Directive defines what is flood risk, some actions to be undertaken, the units of management. Furthermore, it tries to ensure the involvement of all interested parties (Newig et al. 2014). At national level, in England, the 2009 Flood Risk Regulations and the 2010 Flood and Water Management Act implemented the FD by designating the Environment Agency (EA) and Lead Local Flood Authorities (LLFAs) as competent authorities in terms of flood risk management. LLFA in Gloucestershire is the County Council (GCC), which is responsible for the management of flood risk related to groundwater, surface runoff and ordinary watercourse flooding, which is referred to as «local flood risk» (GCC 2014). It usually has operational responsibilities for ordinary water courses and develops a local flood risk management strategy for the Gloucestershire area consistent with the National Flood and Coastal Erosion Risk Management Strategy by the National Department for Environment (DEFRA) and Environment Agency, having the latter a strategic overview on flood risk management for all kinds of flooding and being responsible for main rivers, reservoirs, estuaries and the sea. But in 2012, Gloucestershire County Council has devolved to the local district councils the powers to undertake enforcement to maintain proper flow of water within ordinary watercourses without a necessary consent. Furthermore, the Lower Severn Internal Drainage Board (IDB) has duties to maintain drainage channels and watercourses up to 8 meters above sea levels, so mainly

outside the areas to potentially build interventions to slow the flood upstream. Other actors involved in flood risk governance in the area are: Gloucestershire Highways responsible to drainage water from main roads and the Severn and Trent Water Company, responsible for water supply management, sewage and ground water. A visual representation of this fragmentation is available in Fig. 2.

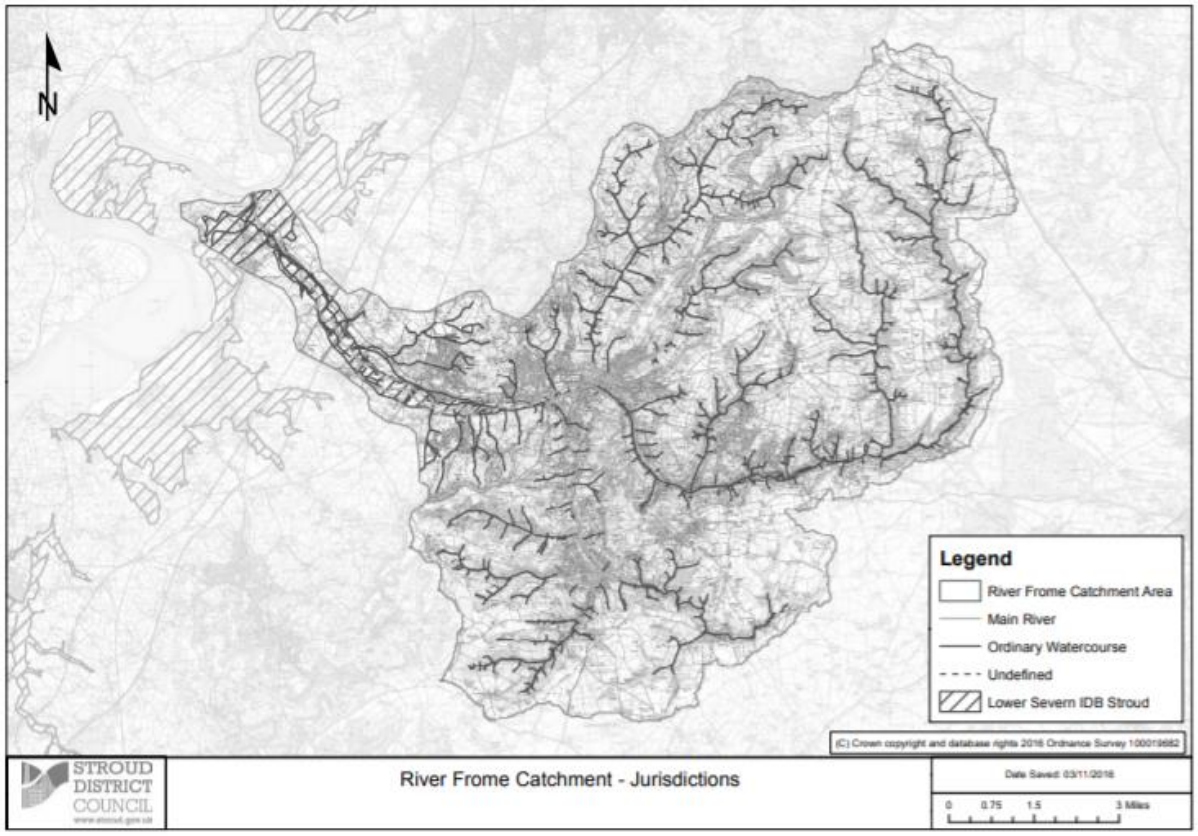

Figure 2 Flood risk management jurisdiction areas in the Frome catchment. Note: The map shows watercourses in the Stroud area by highlighting with different colours the type of watercourse; this to identify the delegated agency for flood risk management (Map by SDC).

3.2 Methodology

We started our fieldwork by contacting the project leader in 2016. With his help a purposive sample was drawn, by considering every actors' typology involved in the project[2]. An actors' map

[2] Among all actors involved, the choice of the interviewees reflected three main criteria. First, their engagement in the project. Second, their vertical risk governance level. Third, their horizontal governance level, and their role in making or not the flood risk management works in practice. So, we successfully had an actor for every vertical level, from the National to the Interregional, County/Regional, Local and very local one. Some names are given in acronym or the role is mentioned in general terms to preserve privacy (see Appendix).

was progressively outlined and 22 semi-structured interviews were undertaken to key actors during 9 weeks spent in Stroud and Gloucester. Life histories or in-depth interviews were also partially suitable because the aim was to unpack meanings, and piece them together to point out relationships, dynamics and practices for reconstructing the history of the project: no official documents, which describe the various stages, exist. During field trips, focused ethnography, walking interviews and visual notes were also undertaken. Indeed, relationships with water, watercourses, environment, built environment and local places are essential, as well as practices. Pictures and visual notes were used to make more understandable the object of the focused ethnography and as a way to translate walking interviews (Clark, Emmel 2010; Evans, Jones 2011) into a decodable text. Furthermore, walking interviews increased «opportunities for the serendipitous and the unanticipated» (Clark, Emmel 2010, 2) to redefine tacit and daily concepts (as the ones linked to local knowledge) by disentangling them. "Walking" was mostly practised where the interviewees led the interview, along any kind of watercourses and run-off paths, on hills and private properties, and where mitigation measures were built. Indeed, non-discursive practices contributed to functionally unveil the *situatedness* and implementation of local knowledges and allowed the researcher to touch with hands the relational aspects of risk, as they are mental images or beliefs, not immediately visible unless in their disastrous consequences, i.e. when risk had turned into a disaster. Data were then manually coded and originally analysed using thematic analysis and critical discourse analysis, by opting for a version of the discourse-historical approach (Wodak, Meyer 2009) in order to identify how discourses constitutes relationships and knowledges and vice versa. Coding included different types of knowledges, different phases of the projects, the risk governance framework (following Renn 2008), place-based data, historical flood data, social-ecological relationships. Therefore, we identified three main phases of the RSUDS project to analyse what happened in Stroud in terms of flood risk management processes driven by the 2007 floods. In this way, local knowledges have been analysed in terms of production, interpretation, practice, validation, use and transmission within the local risk governance framework.

4 Production and integration of local knowledges in risk governance within the RSUDS project

4.1 Acknowledgement and production of local knowledges

In the first phase of the project (2007-2010), which directly followed the 2007 floods, despite not officially foreseen in the ocal risk governance framework, four flood action groups (FAGs)

were born along four streams in the Stroud valley[3] and started promoting meetings with different flood risk management agencies and stakeholders. They aspired to find solutions to mitigate flood risk to avoid future flooding and elaborate some alternative solutions at catchment scale. This was initially done with the help of a local NGO working for water and environmental sustainability, contacted by one of the FAG. In parallel, the Environment Agency came out with contested engineering solutions to reduce flood risk in the area. In particular, two flood action groups were very active: the *SD Group* and *BD Against River Flood*. They were working from time to time jointly, trying to find the best solution to reduce flood risk. Since their very first meetings, they started to build relationships with the main flood risk agencies in order to better understand how to manage flood risk in the area. The SD FAG also started a dialogue with the EA's local representatives, without any practical solutions immediately delivered. Indeed, the EA proposed the construction of two big ponds to reduce flood risk in the SD valley, but the intervention was contested by the public and failed, due to lack of money and geomorphological reasons. In this phase, the District Council was undertaking classic solutions (such as clearing out the streams or flood risk communication campaigns). The other four groups were working autonomously to find solutions for their own stream/brook. The BD FAG was the only one, which tried to promote meetings with the other FAGs.

In this phase, the first idea emerged from the field research was the local conception of «traditional» water management. Local farmers were used to draining water for crops production, that is to drain as fast as possible. Outside of actual flood events, flood risk management was deemed by them as a water management. And «traditional» refers here to consolidated practices:

> I think probably farmers in generally, they would like to think they would clean streams and ditches to keep them free from debris and dig the silt out. But, I think it's probably being kind of productive because that increases the volume of water coming down to the town, which here would had been a big mistake, because a lot of the water is going into the town […] but now I appreciate the benefit of what we have been done (Farmer – 1.6.2017).

So, paradoxically, the work undertaken by the SDC during the project (in the third phase of the process) was to reverse «traditional» local practices of water management in order to alleviate flood risk. To this extent, public participation could have led to wrong practices of flood risk management, if not driven by expert (local) knowledge. To avoid water flowing straight as quick as possible but to find nature-based solutions to slow down the flow and hold water upstream within

[3] *The SD Flood Action Group*, *BD against river Frome flooding*, *PK Flood Action Group*, *RE Flood Action Group*. The *CD River Group*, which was involved in this project, was constituted in 2000.

the catchment: this is the principle which drove the project leader's work. Food production, cattle feeding, economic aspects were the reasons behind this «traditional» (i.e. let water flowing as straight and fast as possible) local way of managing water. Some of these practices and local knowledges were so rooted in common-sense, but they have legal basis, too. Indeed, the 1991 Land Drainage Act partially supported this idea, as well as a bye-laws issues by the local District Council right after a 2001 flood to prevent flood risk (SDC 2002). But then, after the community-driven process, this attitude has been questioned by every actor involved in the project, thus showing the relational aspect of local knowledges and its changing over time. Furthermore, something considered common-sense has turned into something irrational. In terms of flood risk framing, before the 2007 floods, invisibility of both flood risk and flood hazard was something relevant in one of the most affected valley ending up in the town. Indeed, not seeing the brook, again a lack of direct (local) knowledge, increases flood risk, as one of the key actors explained:

> It's all covered over, so the brook has disappeared, it's covered, culverted... This is the SD brook, and so, where the brook comes into the town, into the Stroud town, it's very hidden from people, you don't often see it, so it's in the back of gardens, it's really well far down from the road… you forget… you can't get into the brook, you can't puddle in it… it forms no part of people's life in the town, you know? (SD FAG Chair and County Councillor – 3.11.2016)

In terms of the relationship between risk management and local knowledge, risk awareness also emerged as strictly linked to local knowledges, even if a direct knowledge has been always there but wasn't activated by relationships among people and between people and the environment. The flooding (e.g. in 2007) literally enabled the relationships between some local actors, water and the areas they live by:

> We all lived in our houses and we didn't know each other, we didn't talk, there was no interaction with SDC or the Environment Agency, or anybody! We lived in isolation, we lived in our nice houses and water was here, and suddenly, like that, the water is up here and everybody panics and realizes there's no local knowledge! (PK FAG Chair – 14.4.2017).

Indeed, differently from official opinion, the BD FAG Chair deemed the 2007 flood was not a rare, inevitable, «freak event»[4], rather something «normal». Indeed, he has been living in a flood-prone area downstream, along three watercourses, thus getting all run-off and flooding water

[4] His words.

coming from upstream. The BD location is exactly what makes peculiar flood risk there: three different kind of watercourses managed by three different authorities (Environment Agency, County Council and Highway Authority) resulting in a confusing flood risk governance. The confusion is also marked by a «low number» of properties «at risk» and by the peripheral location, far away from the main town. To tackle this flood risk context, characterized by high risk, a direct knowledge of flooding and a fragmented risk governance, the FAG chair started to learn by himself how to manage flood risk, and then to share his findings to the members of his FAG. In his case, local knowledge turned into citizen science (McEwen, Jones 2012), from the micro-scale of his garden to the catchment scale. His learning and self-legitimization have been driven by common-sense and direct experience: «Because I saw it, because I watched where water goes and I watched how it moves and goes through» (BD FAG Chair – 9.12.2016), he repeated many times. While walking in his garden during the fieldwork he literally explained how he managed to do this over the last years:

> You can't, you can't stop it [flooding]... that's the moment, so once you've realized how – 'cos I've seen it happening... living here… Well, I thought... first I thought it has been scary and then we've sort of began to get used to it, we started to learn… we start at looking around the place and thinking, ah that's what that, so another kind of… oh you will go through a little walk and you will see everything we do, we now rebuilt to resist floods (BD FAG Chair – 9.12.2016)

Watching water flowing, he acquired a local knowledge of water behaviour. He built first a local water geography at a micro-scale (McEwen, Jones 2012), then started to manage flood risk in informal ways. He saw many times water coming into his garden before the 2007 flood and started «interpreting» the water behaviour. So, he adapted his garden by temporary storing water in some parts of it and keeping water flowing without flooding his house. This obviously means there are differences in the local knowledges brought by the different action groups, eventually depending on micro-local contexts. Furthermore, memorialisation of the flooding can be here linked to having directly addressed flooding locally (ibidem). Indeed, who among the interviewees started spontaneously to describe/remember the effects of a flooding is who has been directly affected by the 2007 flood, thus having acquired a direct «local» knowledge of the event, which necessarily influenced his/her risk awareness (Scolobig et al. 2012), risk framing and risk governance's role.

Contrarily, a technocentric vision of risk drove policies and practices of regional and local deputed agencies, which came up with the aforementioned engineering solutions. Indeed, risk was mainly framed by them as:

A purely statistical probability that flood water will impact on a property at certain stages» (Environment Agency Officer – 2.11.2016).

Like in the classic definition of risk, exposure, i.e. the presence of properties, is what «turns» hazard into a risk. What is not strongly considered or slightly hidden is therefore the process that results in flooding. In other words, flooding is not an event but a process.

4.2 Negotiation and validation of local knowledges

In the second phase of RSUDS (2010-2014), there were two parallel dynamics: as time passed and no practical solutions for the whole catchment were found, interest decreased among the public and within the FAG themselves. Only few people were still gathering at the meetings, but these people were determined to find solutions at catchment scale and formed the Stroud Valley Action Forum. The chairs of the SD FAG and the CD FAG, incorporated multiple roles and had a broad social network: they live in flooded areas and already acquired local knowledges of watercourses' behaviours. They have been also political representatives of the Labour and Green parties. The BF FAG chair had also close contacts with the local MP, some journalists and the EA officials: he deliberately thought on strategies to campaign and «make noise» in order to achieve some results. As SD FAG chair and County Councillor, she had access to key actors regarding funding. In parallel, the EA needed to find some solutions, because the SD Brook was partially designated as a main river and as a Rapid Response Catchment in 2012 (so under its responsibility), with 112 properties at risk. After the failure of the proposed solutions, the EA suggested technical and partial measures; among them, the *Individual Property Protection* (IPP) solutions, that is, small interventions at household level to protect only properties at highest risk. In parallel, the EA promoted the dialogue with the flood action groups to consider alternative solutions. The main issue in this phase was to provide a cost-benefit analysis to account for a Natural Flood Management scheme, because only projects with clear targets (in terms of the number of property to be protected according to the amount of money) can be legally funded. The cost-benefit ratio for projects to be funded by the CC should be 1:5, that is a project can be funded with local levy if benefit will raise 5 times the investment. A key role of the SD FAG chair when lobbying in the CC and the RFCC, was to promote a scoping report to assess a possible natural flood management project in the Stroud valley. The report gave some hydraulic and scientific evidence to obtain the funding from the County Council via the RFCC, defining the RSUDS a pilot project. The RE FAG chair was hired as project officer, and had to report to a steering group which was chaired by an elected member of the Stroud District Council and included members of flood action groups.

The path towards the project was rough and not linear. The issue of cost-benefit and the prevalence of an engineering technocratic approach in local flood risk governance partially overcame or ignored local needs and knowledges. For instance, important matters of historical knowledges, to be included or questioned by local ones. First of all, local NGOs also put forward historical justifications for a natural flood management in the valley. It was found that the place name «Stroud»:

> Derives from ancient word «Ströd», which means «a marshy place with brushwood (willow – Salix)». The loss of these natural wetlands profoundly altered the hydraulic response of local watercourses to rainfall, heightening flood (and drought) risk, as well as loss of water quality benefits. The SD Brook comprised extensive ströd, well into the 18th century. Any flood attenuation plans here should restore both the hydrologic and ecologic benefits of these where feasible (Pretto 2008, 16).

The historical knowledge of a place name could thus provide a supportive basis or even a starting point to a local perspective on flood risk management. Furthermore, historical and anecdotal knowledges could work as a sort of natural conditions to be re-established in order to restore an environmental balance, which has been lost. This kind of relationships have thus been partially enabled through direct knowledge and direct engagement with local people, as also institutional actors, like the Environment Agency, acknowledged:

> It was a combination really of the community saying what, yeah, what alternatives are there and primarily, myself, saying, these techniques could work […] They were involved in the primary phase and they were involved once we've got the approval for the project and its funding. They were involved in determining, first of all, exactly what the project leader's role was gonna be and how he was going to work… they were, they very much had a… «steering role», I think it's the best for saying it, isn't it? They worked with us to see where the priorities were, how best to work, how best to deliver those priorities allowing a sufficient scope. So, we were timing specifically, ok the idea was, we know we need the project off, so we need we go to out and talk with landowners and develop projects, but it wasn't known specifically which little projects were going to be delivered, or when and where: that was the project officer determining (Environment Agency Officer – 2.11.2016).

This interviewee reported how public participation influenced the work of the EA in delivering the project: the claim here is to «steer the process»: not to decide what to do (in his opinion), but to keep pushing experimentation, to transmit direct knowledge. This had allowed

nature-based solutions to be implemented, by having criticized classic engineering works, having lobbied, campaigned, and built and rebuilt relationships with water and among institutional actors, within a risk governance perspective. Relationships with local «people in places», that is situated relationships among different governance actors, is what made flood risk management possible. Furthermore, in the relational aspect of local knowledges, knowledge sharing worked as mutual learning, which was initially activated by the community but greatly developed by the project leader while doing his works.

4.3 Reproduction and practical application of local knowledges

In the third and last phase (2014-2017), the governance arrangements of the project included a Strategic group, with representatives from local and national authorities and NGO's with SDC in charge of delivery under the guidance of the national statutory authority, the Environment Agency (EA).

By July 2017, the project had worked with 16 land managers (12 Private and 4 NGO's) and 300 interventions were facilitated, including: 170 Large Woody Debris Dams, 50 minor deflectors, 1 dry-stone wall deflector, 3 spring fed and 3 solar cattle drinking troughs, 5 large earth bunds, 10 small earth bunds/check dams, 6 gulley systems stuffed, 1.7km streamside fencing, 1 large dry pond, 400 trees planted, and many minor interventions. In practice, traditional practices of forestry and land management have been converted into (new) local practises of flood risk management. For instance, coppicing, a traditional technique of forestry management, has been applied by the SDC Project leader for building «leaky dams» following natural flood management principles[5] and common-sense: «To slow down the flow of flood peaks into the valley and divert water onto small floodplains»[6]. The key role was so played by the project leader, which acted as a sort of «local knowledge mediator», negotiating with landowners, farmers, NGOs and local communities how (and where) to adjust the works to be done. In order to plan the work, he acquired a strong local knowledge of the area, mixing up his expert and scientific knowledge (as marine biologist) with direct knowledge of water behaviour, from the catchment to the micro-scale, down to the soil or the micro-gully formed by rain falling. To do the works he contacted local contractors or landowners,

[5] Other techniques used have been used by the Project manager, so called by him:- *flow deflectors*: flows are diverted into an attenuation area where they are temporarily stored until they evaporate or infiltrate; *gully stuffing*: to fill gully with branches to slow down run-off water, prevent erosion and traps silt and sediment. This gully is usually shaped by run-off water; *earth bunds*: to temporary store water and reduce the speed of the surface run-off in case of rainfall events.

[6] Source: www.stroud.gov.uk/rsuds, accessed 16 April 2020.

farmers, and tenants, using their knowledge about local forestry and land management. Most landowners were not usually flooded, as they have been living upstream in the catchment. But they were engaged, thanks to negotiations of the project leader, who mediated different needs and knowledges on a water/river catchment basis. The choice of the actors to be involved upstream was not made by chance, rather first driven by flood risk-related needs, second by social capital, third by having actors who could support the works – such as a big NGO taking care of natural and cultural heritage. For instance, visibility and support given by this NGO could have been exploited to show how this experimental initiative would have positively worked. Furthermore, the social network created by the FAG groups or by local officers, such as a parish councillor, was useful to find supportive landowners. Another very supportive NGO in the area was the Gloucestershire Wildlife Trust, who managed land and undertook installing interventions. The great advantage of RSUDS compared to engineering solutions was that it wasn't necessary to build a unique big solution in a definite place to make the hydraulic modelling working. Contrarily, there was the opportunity to build many little interventions where possible: a key factor in developing measures was that these solutions were installed in locations, which the landowner considered appropriate and thus minimising any potential socio-economic impact.

Focusing on nature-based solutions, natural flood management allowed the District Council to evaluate risk at local level beyond a strictly technical risk characterization. This turned the «risk problem» into a «catchment issue» to be faced by building many small relationships between people, water, and the Project leader. Indeed, another important element of the project leader while building nature-based solutions was literally his way of «learning by walking». If few days were used for doing the work, weeks have been spent walking, talking and looking at soil, water and natural environment.

In order to integrate local knowledges into flood risk management, another key aspect emerged was the issue to identify, validate and share knowledges across scales (Gadgil et al. 2004). The relational and combined nature of local knowledges to face complexity, ambiguity and uncertainty (Renn 2008) needed always to be validated (Raymond et al. 2010) in order to fit into flood risk assessment and management. For instance, controversial stances of «traditional» and anecdotal or historical local knowledges also came out but didn't fit into the project. The references to an ideal past, the believe that the old mills in the area had worked as flood risk attenuation structure, traditional farming and public practices of draining water to manage flood risk: they were all part of a local knowledge domain, which should have been validated. Alternatively, some tacit knowledges and practices, which shaped local knowledges, needed first to be identified in order to

be interpreted and used – like micro-local water run-off and the behaviour of water flowing/flooding, or old place names in the Stroud area.

To conclude, the inclusion of local knowledges resulted in being essential for many reasons to led the RSUDS implementation. First, the narration of rainfall events and water behaviours was indispensable for the project leader to understand the stream behaviour. No maps or other tools could had better evaluated risk than a mix of talking, walking and looking, that is direct knowledge mediated by relationships. So, risk framing resulted in a mix of diverse kind of knowledges, which drove risk evaluation and management. The accumulation and transmission of local knowledges were achieved by local FAG members by talking to each other, with the willingness to learn how to «interpret» the behaviour of riverine and surface run-off water within a local perspective. Ambiguity was here tackled trusting people's expertise in their own areas, assessing risk conditions through direct knowledge and expert one. The notion of «traditional» was locally questioned but not totally rejected: traditional, historical, and local practices and knowledges were mixed up starting from a classic definition of flood risk, which was implemented in a more experimental way, as the Project leader well explained:

> We know if we block the stream, we know the result, so to me the question of proof it's a bit like saying: if we build a wall, a flood defence and it's like 5 cm high it will work for a short period and you understand the wall works? The question is how high the wall needs to be big. Well, with this work it's a parallel question you say, we understand it works, the question is how much and how many we need to build to make the difference… (District Council Officer and RSUDS Project manager – 18.10.2016).

So, uncertainty linked to flood risk was not reduced to a probability rather to a process of building relationships with local actors and water, trying to imitate nature under some common-sense principles. Local knowledges led and shaped the process at the same time, through a co-learning and adaptive co-management process (Huitema et al. 2009) even if public agencies had a clear driving role, opened to experimentation and public participation.

5 Conclusions

Mostly conceived as a «known risk» by expert knowledge, flood risk has been therefore framed as a linear risk problem (Renn et al. 2011) by institutional actors and most of the local stakeholders considered. Furthermore, it was still persistent the idea among some local actors and

institutions, which turned into a need or a desire, to deem flooding as a binary event, so that flood risk should be «reset to zero». Alternatively, after the 2007 floods, in the case study analysed it emerged the idea of flooding as a process, with manifold triggers over space and time. This was a product of locally produced knowledges, mainly due to a change in risk awareness and sometimes preparedness as a result of the production of implicit or explicit direct knowledges. This increased uncertainty, ambiguity and complexity in flood risk assessment and management (Renn 2008) also resulted in the need to include local actors in the risk governance process. The construction or acknowledgement of the relationships between «risk objects» and «objects at risk» (Boholm and Corvellec 2011) influenced the framing, evaluation and management of risk in the local actors affected. This challenged who embodied more traditional and historical components of local knowledges to involve all relevant actors (including not flooded ones) in order to achieve a catchment-based approach. Despite structural asymmetry driven by power relations and expert knowledge in flood risk management (Pellizzoni 1999; McEwen, Jones 2012; De Marchi 2015; Haughton et al. 2015), the RSUDS project was structured so that expert and local knowledges could be shared and considered and the nature-based solutions shaped as a hybrid result. These aspects were particularly clear to the RSUDS project leader. He expressed and followed the need to piece together different knowledges, which derived from a processual and relational notion of flood risk: flood risk was thus not only framed as the probability to affect some properties due to a hazard, rather a process concerning water flowing, land use, forestry management and socio-political relationships. Key factors in terms of effective flood risk governance were local knowledges as essential dimensions to mitigate risk and the progressive acknowledgment of framing flood complexity by local action groups and the project leader.

The case study showed that local knowledges can be deemed something more than «traditional» ones but they are «essentially social» (Wisner 2009). Their acknowledgement, negotiation, production/reproduction and transmission have been undertaken in all the three phases of the bottom-up process analyses. These might be seen not only as stages of co-production but also as key elements in the development and implementation of embedded nature-based solutions within local settings. And the local scale for effective flood risk mitigation was here the river catchment scale, beyond administrative or statutory flood risk or water management duties.

Local knowledges, multifaceted and with different and sometimes contested components (Fischer 2000; Wisner 2009; McEwen, Jones 2012), have been triggered by the flooding/flowing of water and then walking and exploring the areas, and talking with landowners, farmers, NGOs, locals. Indeed, one of the key aspects of natural flood management, and nature-based solutions more generally, is the variability of the works to be done: it’s not always necessary to build big structures

in specific places set by hydraulic models, rather to build as many small interventions as possible where the local knowledges of available landowners, tenants, flood action groups, farmers or local contractors would inform the decision-making process.

REFERENCES

Alexander, M., S. Priest, A.P. Micou, S. Tapsell, C. Green, D. Parker, S. Homewood (2016) *Analysing and evaluating flood risk governance in England. Enhancing societal resilience through comprehensive and aligned flood risk governance*, STAR-FLOOD Consortium, Flood Hazard Research Centre at Middlesex University.

Barredo, J.I. (2009) *Normalised flood losses in Europe*: 1976-2006, in «Natural Hazards and Earth System Science», 9, pp. 97-104.

Blaikie, P., K. Brown, M. Stocking, L. Tang, P. Dixon, P. Sillitoe (1997) *Knowledge in action: local knowledge as a development resource and barriers to its incorporation in natural resource research and development*, in «Agricultural Systems», 55, 2, pp. 217-37.

Boholm A, H. Corvellec (2011) *A relational theory of risk*, in «Journal of Risk Research», 14, 2, pp. 175-90.

Clark, A., N. Emmel (2010) *Realities Toolkit #13. Using walking interviews*, in «Realities», available online at: http://eprints.ncrm.ac.uk/1323/1/13- toolkit-walking-interviews.pdf, accessed 3 August 2017.

De Marchi, B. (2008) *Public participation and risk governance*, in «Science and Public Policy», 30, 3, pp. 171-76.

De Marchi, B. (2015) *Risk governance and the integration of different types of knowledge*, in U. Fra Paleo, ed., *Risk Governance. The articulation of hazard, politics and ecology*, New York, Springer, pp. 149-65.

De Marchi, B., L. Pellizzoni, D. Ungaro (2001) *Il rischio ambientale*, Bologna, Il Mulino.

Ellen, R., H. Harris (2000) *Introduction*, in R. Ellen, P. Parkes, A. Bicker, eds., *Indigenous environmental knowledge and its transformations. Critical Anthropological Perspectives*, Amsterdam, Hardwood Academic Publishers.

EP (2007) *Directive 2007/CE/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks*, available online at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF /?uri=CELEX:32007L0060&from=en, accessed 4 August 2017.

Evans, J., P. Jones (2011) *The walking interview: methodology, mobility and place*, in «Applied Geography», 31, pp. 849-58.

Fischer, F. (2000) *Citizens, experts and the environment. The politics of local knowledge*, Durham-London, Duke University Press.

Forino, G. (2015) *Per un approccio globale alla riduzione del rischio da disastri. Note a margine della Third UN World Conference on Disaster Risk Reduction*, in «Il Lavoro Culturale», available online at: http://www. lavoroculturale.org/per-un-approccio-globale-alla-riduzione-del-rischio-dadisastri/, accessed 5 July 2017.

Funtowicz, S.O., J.R. Ravetz (1992) *Three types of risk assessment and the emergence of post-normal science*, in S. Krimsky, D. Golding, eds., Social Theories of Risk, Westport, Praeger, pp. 251-74.

Gadgil, M., P. Olsson, F. Berkes, C. Folke (2004) *Exploring the role of local ecological knowledge in ecosystem management: three case studies*, in F. Berkes, J. Colding, C. Folke, eds., *Navigating Social-Ecological Systems Building Resilience for Complexity and Change*, Cambridge, Cambridge University Press.

Gaillard, J.C., J. Mercer (2012) *From knowledge to action: bridging gaps in disaster risk reduction*, in «Progress in Human Geography», 37, 1, pp. 93-114.

Gloucestershire County Council (GCC) (2014) *Local flood risk management strategy*, available online at: http://www.gloucestershire.gov.uk/your-community/emergencies-and-your-safety/flooding-and-drainage/gloucestershirecounty-councils-local-flood-risk-management-strategy-lfrms/, accessed 22 September 2017.

Haughton, G., G. Bankoff, T.J. Coulthard (2015) *In search of 'lost knowledge' and outsourced expertise in flood risk management*, in «Transactions of the Institute of British Geographers», 40, pp. 375-86.

Hiwasaki, L., E. Luna, R. Syamsidik Shaw (2014) *Local and indigenous knowledge for community resilience: Hydro-meteorological disaster risk reduction and climate change adaptation in coastal and small island communities*, Djakarta, UNESCO.

Huitema, D., E. Mostert, W. Egas, S. Moellenkamp, C. Pahl-Wostl, R. Yalcin (2009) *Adaptive water governance: assessing the institutional prescriptions of adaptive (co-) management from a governance perspective and defining a research agenda*, in «Ecology and Society», 14, 1, pp. 8-26.

Krieger, K. (2013). *The limits and variety of risk-based governance: The case of flood management in Germany and England*, in «Regulation and Governance», 7, pp. 236-57.

McEwen, L., O. Jones (2012) *Building local/lay flood knowledge into community flood resilience planning after the July 2007 floods, Gloucestershire, UK*, in «Hydrology Research», 43, 5, pp. 675-88.

Mercer, J., I. Kelman, L. Taranis, S. Suchet-Pearson (2010) *Framework for integrating indigenous and scientific knowledge for disaster risk reduction*, in «Disasters», 34, 1, pp. 214-39.

Mercer, J. (2012) *Knowledge and disaster risk reduction*, in B. Wisner, J.C. Gaillard, I. Kelman, eds., *The Routledge Handbook of Hazards and Disaster Risk Reduction*, New York, Routledge.

Newig, J., E. Challies, N.W. Jager, E. Kochskämper (2014) *What Role for Public Participation in Implementing the EU Floods Directive? A comparison with the Water Framework Directive, early evidence from Germany, and a research agenda*, in «Environmental Policy and Governance», 24, 4, pp. 275-88.

Pellizzoni, L. (1999) *Reflexive Modernization and beyond. Knowledge and value in the politics of environment and technology*, in «Theory, Culture and Society», 16, 4, pp. 99-125.

Pretto, I. (2008) *Slad Brook Pilot: Hydrological Modelling and Flood Alleviation Solutions*, in «Water 21», available online at: http://www.water21.org.

uk/wpontent/uploads/2011/09/SLAD_BROOK_PILOT_Ilaria_Pretto_Water21_Aug_08.pdf, accessed 15 October 2017.

Raymond, C.M., I. Fazey, M.S. Reed, L.C. Stringer, G.M. Robinson, A.C. Evely (2010) *Integrating local and scientific knowledge for environmental management*, in «Journal of Environmental Management», 91, pp. 1766-77.

Renn, O. (2008) *Risk Governance. Coping with uncertainty in a complex world*, New York, Routledge.

Renn, O., A. Klinke, M.B.A. Van Asselt (2011) *Coping with complexity, uncertainty and ambiguity in risk governance: a synthesis*, in «AMBIO», 40, pp. 231-46.

Scolobig A., B. De Marchi, M. Borga (2012) *The missing link between flood risk awareness and preparedness: findings from case studies in an Alpine Region*, in «Natural Hazards», 63, pp. 499-520.

Stroud District Council (SDC) (2002) *Land drainage bye-laws*, Stroud, Environmental Health Service.

Scottish Environment Protection Agency (SEPA) (2015) *Natural Flood Management Handbook*, available online: https://www.sepa.org.uk/media/163560/ sepa-natural-flood-management-handbook1.pdf, accessed 3 August 2017.

Shaw, R., A. Sharma, T. Takeuchi (2009) *Indigenous Knowledge and Disaster Risk Reduction: From Practice to Policy*, Tokyo, Nova Science Publisher.

Short, C., L. Clarke, F. Carnelli, C. Uttley, B. Smith (2019) *Capturing the multiple benefits associated with nature-based solutions: lessons from natural flood management project in the Cotswolds, UK*, in «Land Degradation and Development», 30, 3, pp. 241-52.

Sillitoe, P. (2007) *Local science vs. global science: Approaches to indigenous knowledge in international development*, Berlin, Berghahn Books.

Spiekermann, R., S. Kienberg, J. Norton, F. Briones, J. Weichselgartner (2015) *The disaster-knowledge matrix – Reframing and evaluating the knowledge challenges in disaster risk reduction*, in «International Journal of Disaster Risk Reduction», 13, pp. 96-108.

UNISDR (2005) *HYOGO framework for Action 2005-2015 (HFA): Building Resilience of Nations and Communities to Disasters*, available online at: http://un-documents.net/hfa.htm, accessed 9 February 2018.

UNISDR (2015) *Sendai Framework for Disaster Risk Reduction 2015-2030*, available online at: https://www.unisdr.org/files/43291_sendaiframeworkfordrren.pdf, accessed 1 August 2017.

Waylen, K.A., K.L. Holstead, K. Colley, J. Hopkins (2017) *Challenges to enabling and implementing Natural Flood Management in Scotland*, in «Journal of Flood Risk Management», 11, S2, pp. S1078-89.

Weichselgartner, J., P. Pigeon (2015) *The role of knowledge in Disaster Risk Reduction*, in «International Journal of Disaster Risk Science», 6, pp. 107-16.

Wisner, B. (2009) *Local Knowledge and Disaster Risk Reduction. Keynote speech delivered at the Side Meeting on Indigenous Knowledge Global Platform for Disaster Risk Reduction*, Geneva, 25th June 2009, available online at:

www.radixonline.org/resources/WisnerLocalKnowledgeDRR_25-6-09.doc, accessed 1 June 2017.

Wodak, R., M. Meyer (2009) *Methods of Critical Discourse Analysis*, London, Sage.

Wynne, B. (1996) *May the sheep safely graze? A reflexive view of the expert-lay knowledge divide*, in S. Lash, B. Szerszynski, B. Wynne, eds., *Risk, Environment and Modernity. Towards a New Ecology*, London, Sage.

Appendix

A list of the interviewees with their role in the project and in local flood risk governance

Governance Level	**Agency/Type**	**Role**
District/Local	Stroud District Council (SDC) – Env. Health Office + RE Brook Action Group	Project leader + Community groups (Flood Action Group – FAG) chair
District/Local	SDC – Env. Health Office	Water resource engineer
District/Local	SDC – Env. Health Office	Chief
District/Local	SDC	Steering Group Chair
Local/Parish	Woodchester Parish	Clerk
County	Gloucestershire County Council (GCC)	Flood Risk Manager
Regional/County	Severn and Wye Regional Flood and Coastal Committee/GCC/IDB	Councillor
Regional	Environment Agency (EA)	Env. Programming Adviser
Regional	Lower Severn Internal Drainage Board (IDB)	Chair
National	House of Commons	Local MP
National	Local Nature Partnership	Former Chief Executive Countryside Com.
County/Local	SD Flood Action Group/GCC	Councillor + FAG chair
Local	PK Stream Management Group	FAG chair
Local	CD River Group	FAG chair
Local	BD Against Flood Risk	FAG chair
Local	Water 21 NGO	Local water expert
Local/National	National Trust NGO	Local Ranger
Local	SD FAG + flooded inhabitant	FAG Secretary
Local	Local hydrologist	Consultant
Local	Wickstreet Farm	Farmer
Local	Landowner	Landowner
Local	Contractor	Contractor