# Flood Risk Management: Association of Municipalities along the River Aist in Austria - Does the theory on inter-local associations of municipalities apply to a project in practice?

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Written by

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Abstract of a thesis submitted in partial fulfilment of the requirements for the joint Degree of Master of Natural Resources Management and Ecological Engineering.

# Flood Risk Management: Association of Municipalities along the River Aist in Austria - Does the theory on inter-local associations of municipalities apply to a project in practice?

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**Abstract**

Socio-hydrology, management and adaptation strategies as well as ways of coping with the hazard are important factors in flood risk management. In case of a catchment-based approach, co-operation between upstream and downstream parties is the basis for a successful management strategy. In this thesis a literature review was carried out for gathering information on the theoretical background concerning socio-hydrology, natural hazard problems and adaptation, and upstream and downstream co-operation in flood risk management. To see whether the theory is applied in practice, an example of an association of municipalites in the catchment area of the river Aist in Upper Austria was chosen, a qualitative interview carried out and the collected data compared with the literature. As the results show, the inter-local co-operation along the Aist can be used as a model for catchment-oriented flood risk management, although it needs to be considered that every catchment has its own characteristics and adjustments need to be made to suit the individual properties.

**Keywords:** Socio-hydrology, Flood risk management, Inter-local co-operation, Upstream-downstream co-operation, Vulnerability, Catchment-based approach, River Aist.

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# Table of Contents

**Flood Risk Management: Association of Municipalities along the River Aist in Austria - Does the theory on inter-local associations of municipalities apply to a project in practice?**

# List of Tables

# List of Figures

# Chapter 1

# Introduction

## 1.1 Problem statement

***"Water represents a key aspect of sustainability challenges facing humans in the Anthropocene"***

**(Sivapalan et al. 2014, p. 225)**

This point of view has existed for about half a century but until the last decades water has not received the attention from the scientific world it actually deserves. For a long time, in international meetings other topics seemed of higher relevance and got more attention by scientists than water, until in the 1980´s. This was when the integrated management of water became an important issue in the political and scientific world (Blair et al. 2016; Savenije et al. 2008). A shift in the framing of water took place, indicated by the differentiation of water "development" to water "management" showing the establishment of a more holistic mindset (Blair et al. 2016).

As water-cycle dynamics are influenced with accelerating speed by the human appropriation of water resources and by the ongoing modification of landscapes in different spatial as well as time scales, the effects of human actions nowadays reach from local to global and from months to centuries. These currently arising unpredictable and surprising ways of water sustainability challenges created by human actions need to be integrated into new approaches to water management and hydrological science (Sivapalan et al. 2014).

In case of the catchment area along the river Aist in Upper Austria, Austria, which is the field of practice in this thesis, finding a new approach towards water management was necessary. Since more than a decade the settlements in the catchment were subject to flooding on a regular basis (Puchinger. n.d.). In 2002, the damages were as severe that public authorities, together with the Austrian Service for Torrent and Avalanche Control, put a regional study in execution, to identify which measures for the protection and mitigation against flood events were possible to be executed in the whole catchment. This was the beginning of the establishment of the inter-local co-operation, because it was clear to all the stakeholders, that a project of this size, in a catchment area of about 640km², can only be successful if all the affected municipalities co-operate (Hochwasserschutzverband Aist. n.d.).

As a result, the association of municipalities was established in 2007 and according to their official website, apart from several completed measures, at this point there are still some projects either not implemented yet, or put on hold (Hochwasserschutzverband Aist. 2014). This caught my attention and the question arose, if this certain inter-local co-operation would apply to what the literature says about successful implementation of such associations of municipalities.

## 1.2 Objective of the thesis and research questions

The central objective of this thesis is to find out if the theory from the literature about flood risk management strategies and approaches, and upstream – downstream co-operation which is applied in an inter-local co-operation of municipalities along the river Aist in Upper Austria, comply with each other. The research questions are as follows:

1. Is the co-operation between the municipalities in the catchment area of the Aist successful?

2. Was the goal, to protect the catchment from flood events with a 100-year reoccurrence, reached?

3. Was there a change in strategy since the inter-local co-operation was established?

4. Did difficulties in reaching the goal arise?

## 1.3 Outline of the thesis

This thesis is structured into eight chapters. The first one is the introduction, which will give you an overview of the problem statement, the objective and the outline of the thesis. The next three chapters are based on literature and discuss theoretical issues that are part of water management and should give a deeper insight into the topic of water recourses management and show a variety of issues which are included in this broad topic of flood risk management.

The second chapter is called "Socio-hydrology" which presents the development from ancient hydrological management strategies towards the development of socio-hydrology, and additionally names three international initiatives which played an important role in the development of "the new science of people and water", as socio-hydrology is also called.

Chapter three discusses problems with natural hazards and possible ways of adapting to them. The hazard which is mainly discussed are flood events. Vulnerability is mentioned since it is a central topic when it comes to natural hazards, as a natural event only becomes a hazard when people and economic values are involved. Furthermore, self-responsibility, which is often neglected through the existence of different forms of insurance is a topic which belongs to “natural hazard problems and adaptation” and is illustrated in this chapter too.

The last literature-based chapter, chapter four, talks about the co-operation of upstream and downstream communities along rivers. Partnership approaches in catchments, inter-local co-operation arrangements are the central part of this section. Moreover, different approaches of flood risk management on a catchment scale in Europe are introduced.

The thesis then continues with the methodology of this work. The qualitative research method and grounded theory are mentioned, and the tool used, a structured interview, is shortly explained.

The main part of this thesis is chapter six, which describes the mitigation of flood risk in Austria and talks about legal tools. Then, the inter-local association of municipalities along the river Aist in Upper Austria, Austria is introduced. Hard facts about the catchment of the Aist and about the association, but also some legal tools concerning the various ways of financing of this union are presented. These are included to create a better understanding of how floods are handled in Austria. Moreover, this chapter contains a transcribed radio interview from 2013 with the chairman of the association, gives an insight of the civil initiative that was founded in the Aist catchment and presents the results gathered with the help of the qualitative interview.

Chapter seven comprises the results and compares the gathered information from the literature review with the answers from the experts collected with the help of the structured interview. This section is then followed by the conclusion of the thesis where the research questions are answered, and it then finishes off with the reference list.

# Chapter 2

# Socio-hydrology

## 2.1 A historical overview on the development from ancient hydrology towards socio-hydrology

### 2.1.1 Ancient hydrology

***"Water is the original substance, and hence is the material cause of all things. "***

**(Thales. ca. 600 B.C)**

Mankind realized from the early beginnings that water is vitally important for survival, hence water resources management was developed in ancient times. Listings of only a few examples of hydraulic engineering prior to 600 B.C. can be viewed in table 1.

| WHEN | WHERE | WHAT | PURPOSE |
|---|---|---|---|
| | | | |
| 4000 B.C. | Mesopotamia | Canals | Irrigation |
| 3200 B.C. | Egypt | Canals | Water supply |
| 2950 -2750 B.C. | Egypt | Dam | Drinking water |
| 2750 B.C. | India | Water supply and Drainage system | Water supply and Drainage |
| 2280 B.C. | China | Waterworks, Dams, Dikes | Specific purpose unknown |
| 2160 –1788 B.C. | Egypt | Artificial Lakes | Flood control |

Table 1: Examples of hydraulic engineering prior to 600 B.C. (from Biswas. 1970; Nace. 1964).

Dating back to about 4000 B.C. or even earlier, one of the first evidences of water resources work in form of an irrigation system was built by the Sumerians in the Mesopotamian plain (which is in today´s Syria and Iraq). Its size of probably 20.000 km² and its longevity are impressive for such an early construction (Nace. 1964). In 3200 B.C. under the reign of King Scorpion in Egypt, man-made canals most likely for water supply were constructed (Biswas. 1970). Besides the Nile in Egypt, the Tigris and Euphrates in Mesopotamia, there is evidence of earliest civilizations along other rivers like the Indus in India as well as along the Yellow River in China (Biswas. 1970; Nace. 1964).

Biswas (1970) states that the oldest dam in the world, found in the Wadi el-Garawi in Egypt, was probably built during the third or fourth dynasty (from around 2950 – 2750 B.C.) to supply drinking water for workmen and animals of a nearby quarry. In about 2750 B.C. the Indus Valley water supply and drainage systems originated and in China Emperor Yau ordered the construction of waterworks, dams and dikes in about 2280 B.C. Furthermore, during the Middle Kingdom in Egypt (2160 – 1788 B.C.) artificial lakes were used for flood control purposes at the Nile. The most famous one, known by the name Lake Moeris back then, is nowadays called Birket or Lake Qarun located in the north-eastern part of Egypt (Biswas. 1970).

The presence of old structures shows that already around 600 B.C. more complex water supply systems were developed. Just to name an example; when King Sennacherib of Assyria reigned, water was diverted from the clean river Khosr to the city of Nineveh, the capital of Assyria (in ancient Mesopotamia) where he was living. This was done by constructing weirs, canals and dams. However, the development of more complex systems was not only Kings´ Sennacherib of Assyria accomplishment. Around his time, it commenced that hydrologic engineering gained more importance, including successful planning, design, construction, operation as well as maintenance of the constructions. For this reason these early cultures can be called “hydraulic civilizations” without hesitation (Biswas. 1970).

Rainfall measurements, using rain gauges have first been recorded in about 300 B.C. The earliest evidence was found in India, followed by China where from 200 B.C. it was order that every country had to measure the monthly rainfall and report it to the central government. This was their way of taxing people for land – according to the monthly rainfall (Biswas. 1970; Dooge. 2004).

From about 800 B.C. people started using water power. According to Dooge (2004), in antiquity it was mainly used for grinding corn. In the early middle ages (around 500 A.D.) water mills were further developed, until in the 11$^{th}$ century water power was further used in the production of hemp and oil, as well as for malting. Towards the end of the middle ages, approaching the 15$^{th}$ century, producing cutlery, wood turning, paper milling and other processes were carried out with the help of water power (Dooge. 2004).

Later on, in the 17th century after a few more or less well-known personalities, including Thales, showed interest in exploring the water cycle, "hydrology was launched towards its modern course" (Nace. 1969, p. 28) which will be dealt with in the following sections.

### 2.1.2 The 20th century and issues of rapid population growth

In the 1950´s, when societies were growing rapidly, new ways of managing resources had to be found, in order to make sure that everybody was to get his or her share of the available resources – to be able to survive (United Nations. 2009). It was believed that extensive agriculture and energy production were the best solutions to the problem (Davis. 1985). The "green revolution" in the 1960´s to 1970´s was one major step in providing increasing amounts of food for a growing worldwide demand. Modern plant breeding, high technological advances in machinery, fertilizers as well as newly developed pesticides were introduced to counter steer the expected starvation in the second half of the 20th century, which it successfully did. Common problems however, which this revolution brought about were the degradation of the environment, increasing inequalities in income and asset distribution, plus a worsening of absolute poverty of people (International Food Policy Research Institute. 2002).

Water is a big issue and essential for the survival of every living species on the planet (Biswas. 1970). In the green revolution a higher demand in food was coinciding with a larger consumption of water; needed for drinking water supply, watering plants in agriculture and water use of the faster growing industries. Until then water has always been available in sufficient amounts and quality (apart from areas of droughts and deserts) and was taken for granted by its consumers. Nobody had considered, that one day the need for water resources management could become an issue, until in 1965 the UNESCO created the first programme on global hydrological studies – the International Hydrological Decade (IHD). In section 2.2.1 the IHD is described in more detail.

### 2.1.3 From water resources management (WRM) to integrated water resources management (IWRM)

The exhaustion of the environment, especially of water, has continued until the 1980´s. When the Brundtland report was submitted in 1987 by the World Commission of Environment and Development, it was first recognized that overexploitation of water resources was actually possible. Nevertheless, it was a prevailing issue. Social as well as ecological constraints were accounted for on a large scale in hydrological science (Savenije. 1996; Savenije et al. 2008).

Really effective water resources management, according to Savenije (1996), should definitely include the involvement of stakeholders to achieve commitment plus flexibility in approach and in planning tools.

In contrast to opening individual projects facing overexploitation like it has been previously done, regional and national planning for the management of water in an integrated manner were launched. In the 1980´s to 1990´s when the scientific world started to become attentive to demand-side measures (Savenije et al. 2008).

In the 1990´s a shift in thinking took place (Hartmann. 2011; Savenije et al. 2008) – the new paradigm was preserving the environment in contrast to degrading it. Environmental protection, public participation and sustainability were taken up upon by scientists (Savenije et al. 2008). Water management was no longer practiced in a top-down manner and the sector by sector way of management has shifted to one where the interconnectedness of waterbodies and hydrological resources was accounted for (Savenije et al. 2008; Thaler. 2014; United Nations Environment Programme. n.d.). Furthermore, not only physical aspects but also aspects regarding institution, finance, economy, legality, environment and society should be added to the now called "comprehensive management of water" (Mitchell. 2005; Savenije. 1996; Savenije et al. 2008).

Since in 1992 the International Conference on Water and the Environment was held in Dublin, integrated water resources management became a guiding principle being called the "holistic" approach (Mitchell. 2005; Nachtnebel et al. 2009). Additionally, decentralized decision making, another new established form of governing, was accepted since the Dublin conference, meaning that only decisions which cannot be taken by the lower institutional levels are taken by the institutional top levels (Savenije et al. 2008).

The four dimensions of water namely water resources, water users, spatial scale and temporal scale make up the IWRM (Sivapalan et al. 2012). This discipline, although the focus lies on the interaction of connected systems, it still considers one or the other system separately (as a boundary condition). It focuses on one-way interactions and thinks in rather short times scales or even supposes the structure of a system to be fixed in time (Blair et al. 2016; Montanari et al. 2013). This is different in socio-hydrology which will be presented in detail in chapter 2.3, after some essential international initiatives, which led to the development of socio-hydrology, are mentioned in the following part.

## 2.2 International initiatives dedicated to water sciences

For the development of socio-hydrology the following initiatives were of great importance.

### 2.2.1 The International Hydrological Decade (IHD)

After the International Geophysical Year (1957-58) and a world water shortage in 1956, it became apparent to scientists globally that international scientific collaboration in the whole water sector, especially for water resources management, was needed. This, in 1965, launched the initiation of the International Hydrological Decade (IHD) declared open by the UNESCO, being the first programme worldwide on hydrological studies (Bock. 1965; Meadows. 2014; Nace. 1965). The IHD, lasting until 1974, was meant to be a strategic programme, focusing on the systematic study and reasonable use of water; educating people in hydrology, both in developed or developing countries. To tackle problems concerning water resources without the need of external help was the overall goal (Walton. 1966). The IHD should be of high significance for hydrologists contributing to an increased human welfare not only currently but also for future generations to come (Nace. 1964).

### 2.2.2 The International Hydrological Programme (IHP)

In 1975, when the IHD was over, water resources management was still an important topic with a lot of issues to be solved on a global scale. Governments and the international scientific community were demanding for an internationally coordinated programme focusing on water, which subsequently led to the evolvement of the International Hydrological Programme of the UNESCO (United Nations. 2009). It is the only intergovernmental programme of the United Nations designated to water research so far (Meadows. 2014; Rodda. 1996; Volker et al. 1995). The created awareness for this important issue may have also led to the submission of the Brundland report in 1987.

Currently we have entered the eighth phase of the IHP (from 2014- 2021) entitled “Water Security: Responses to Local, Regional and Global Challenges”. The international goal of this phase is to integrate the inevitable interconnectedness of different disciplines by working out policies for holistic, multi-disciplinary and sustainable approaches to integrated water resources management and water protection (Meadows. 2014; UNESCO. 2012). The label of the IHP can be viewed in figure 1.

Figure 1: Label of the International Hydrological Programme (IHP) (from UNESCO. 2012).

### 2.2.3 The International Association of Hydrological Sciences (IAHS)

IAHS, the international Association of Hydrological Sciences, is a scientific non-profit international non-governmental organization coordinating the achievements of the hydrological community globally. Having expanded and grown from only nine member countries worldwide when inaugurated, it holds more than 5000 members today and has expanded to 67 countries all across the planet (Ismail-Zadeh et al. 2009; Rodda. 1996).

The International Union of Geodesy and Geophysics (IUGG) after its establishment in 1919, started off with six sections, also named associations. The hydrology association was created three years after the union´s inauguration, namely in 1922. Currently, the IUGG consists of eight semi-autonomous international associations, each working on their specific themes. The IAHS is the one of them (Ismail-Zadeh et al. 2009).

The IAHS´s “function is to project the legacy of hydrology into the future with continuity, by taking advantage of the best from human and technical resources” (Montanari et al. 2013, p. 1262). This lively organization has a long and well-known record of improving hydrological knowledge and practice through conducted activities worldwide. Published research results clearly show that IAHS research initiatives play a role of great importance in the development of hydrological sciences (Montanari et al. 2013).

Furthermore, some common interests are shared with several UN bodies (UNESCO – United Nations Educational, Scientific and Cultural Organization, WMO – World Meteorological Organization, IAEA – International Atomic Energy Agency, UN Water) and besides that, reports and proceedings (“red books”), publications (“blue books”) and journals about hydrology are being issued on a regular basis. Moreover, programmes in hydrology of the UNESCO and WMO were created by the IAHS (Rodda. 1996). “Hydrology 2020”, a working group put together by the IAHS in 2001, consisting of 12 hydrologists and specialists working on themes of water resources worldwide, are addressing predicted water challenges on a global basis up to the year 2020 (Oki et al. 2006).

The years 2003-2012 are called the IAHS scientific decade (an initiative created by the IAHS) of "predictions in ungauged basins (PUB)". Besides the gathering of a more fundamental knowledge about hydrological processes, the aim of this scientific decade was to develop more realistic models which are used for future predictions (Hrachowitz et al. 2013).

The recent scientific decade, from 2013 to 2022, has the theme "Panta Rhei – Everything Flows. A Change in Hydrology and Society". This famous quote by Heraclitus, an ancient Greek philosopher, implies that everything is in a process of constant change. As the title reveals, this scientific decade focuses on research activities on changes in hydrology and society as a global initiative. Figure 2 shows its logo. Creating this scientific decade emerged from the international need in getting a better insight in hydrological change in connection with changes occurring in society (Montanari et al. 2013). The emergence of the new science socio-hydrology at the beginning of this scientific decade therefore fits in perfectly.

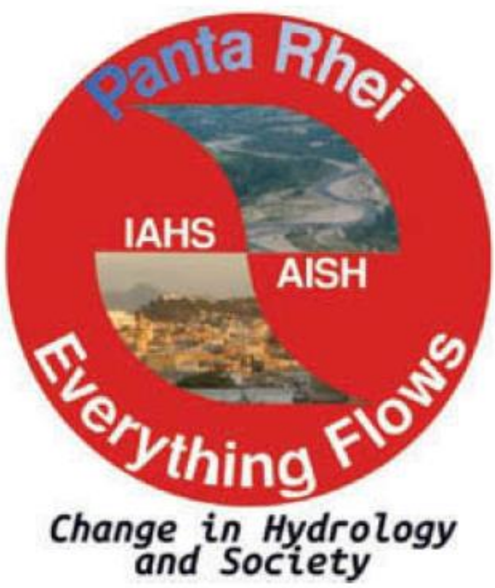


Figure 2: Logo of the recent IAHS (International Association of Hydrological Sciences) scientific decade "Panta Rhei – Everything Flows" (from Montanari et al. 2013, p. 1265).

## 2.3 Socio-hydrology in flood risk management: dynamics and co-evolution of coupled human-water systems

***"Floods are acts of god, but flood losses are largely acts of man."***

**(Gilbert F. White. ca. 1945)**

Socio-hydrology, "a new science of people and water" (Sivapalan et al. 2012, p. 1270), which was introduced by Sivapalan et al. in 2012 is an interdisciplinary approach linking water and society (Di Baldassarre et al. 2013). Regardless of the fact that socio-hydrology is still in its infancy, this "new direction in hydrological science" (Wesselink et al. 2017, p. 2) is important because all bodies of water on this planet are affected by people in any kind, and vice versa (Loucks. 2015; Troy et al. 2015).

Due to the fact that integrated water resources management (IWRM) includes some downsides and scientists are eager to constantly find new technology and practical solutions, socio-hydrology came into existence. This newly created approach is the research theme for this present hydrological decade (from 2013-2022) "Panta Rhei – Everything flows" (Wesselink et al. 2017); also see section 2.2.1.

Socio-hydrology is an interdisciplinary, however quantitative study of water and people; of coupled human-water systems which developed out of IWRM (Sivapalan et al. 2012; Troy et al. 2015). Humans are important components of the water system as well as part of the water cycle dynamics and it is the aim of socio-hydrology to predict the dynamics of either of them.

In IWRM the assessment of the impact of change was carried out on the basis of the scenario-based approach (Blair et al. 2016; Sivapalan et al. 2012; Wesselink et al. 2017), which is no longer practical for socio-hydrological studies. In the early 2000´s the interests of scientists shifted from the technical focus of hydrology towards the inclusion of humans and society in hydrological issues. The interaction between humans and water is to be studied and represented more deeply than in the previous decade, as it is connected to sustainable water use as well as to sustainable human development. These two factors can be seen as the main drivers of change in human-water systems and are therefore important to be looked at. Particular focus of this interdisciplinary study lies on the bi-directional, two-way interaction and the feedbacks created by the co-evolution of humans and water with the involvement of longer time scales than ever considered (Blair et al. 2016; Gleick. 2003; Montanari et al. 2013; Sivapalan et al. 2012; Sivapalan et al. 2014).

In this thesis, the focus lies on the part of socio-hydrology in flood risk management which deals with the subject of how flooding influences peoples´ settlements and behaviour towards water, as well as how human actions influence flooding in frequency and magnitude (Di Baldassarre et al. 2013).

In order to understand flood dynamics and how people can be protected from them, an awareness for people´s environment needs to be created. Mitigation is one of the current strategies coping with people being affected by hydrological processes (Di Baldassarre et al. 2014). It is important however, not only to grasp hydrological processes but also to be aware of the interplay between physical and social processes; between people and water (Di Baldassarre et al. 2015).

Di Baldassarre et al. (2013) propose a conceptualization of the dynamics for inhabited, urban floodplains where they want to show that communities implementing non-structural measures against floods are more resilient than communities relying on structural protection measures. Table 2 lists structural versus non-structural measures against flooding in urban areas.

| Structural protection measures | Non-structural protection measures |
| --- | --- |
| • Dams<br>• Levees<br>• Storm water drainage systems<br>• Retention areas and reservoirs for flood water | • Public education and training<br>• Forecasting and warning systems<br>• Building and planning codes<br>• Increased natural retention capacity<br>• Land use management<br>• Implementation of adaptive flood management policies |

Table 2: Structural and non-structural protection measures against flood risk (from Loucks. 2015; Schober. 2013).

Di Baldassarre et al. (2013) created a model which suggests a scenario of a community that starts settling near a river which is prone to flooding. The benefits of the river (i.e. trade, good soil quality) attract the human settlement until the occurrence of a flood causes damages to the community. People are shocked and awareness for vulnerability to flooding is firstly created. Now, there are two options: either people start moving further away from the river which implies losing the economic benefits of the proximity to the river, or they start building structural protection measures against future damages created by water in case of flooding.

The second option, building structural measures, is also connected with a declination of benefits (mainly economic benefits because building costs arise for the construction of dams or levees and therefore cannot be spent on other economic investments). Furthermore, a combination of both scenarios is also possible. The installation of structural protection measures creates a feedback on the hydrological system, as high water levels may be intensified, the attenuation of floods may be alleviated and the conveyance of the cross section may be reduced. At this point it needs to be said, that it is obvious that some communities have more resources than others and that this scenario neglects the heterogeneity of human settlements.

Continuing, an empirical study of local flood response by Heine et al. (2012) shows, that the presence of levees considerably increases high water levels. Moreover, the awareness of flood risk towards the community decays over time, so due to the economic benefits there is the tendency of moving closer to the river after the memory of the risk is lost. “The less a flood is expected, the more severe it will be” (Hartmann. 2011, p. 2). How long after an event, the process of approaching the river again is initiated, strongly depends on the memory of the community and the ability to keeping up the awareness of risk.

In the conceptualization by Di Baldassarre et al. (2013) five types of processes are considered: hydrological, political, economic, technological and social processes. They are interconnected and co-evolve successively over time. If a flood event occurs they are all suddenly altered (Di Baldassarre et al. 2013). Either of the following processes is changed by the hydrology of flooding which in return is influenced by each process:

- Politics: the memory of prior events and awareness of being vulnerable to floods trigger, if the ability is given, the incentive to move further away from the river. As being close to the river opens the possibility of maximizing the economic benefit, a trade-off is created between proximity and the possibility of being at risk.
- Economics: in general, the size of a human settlement (including the number of people, the physical size and the economic wealth) changes over time. On the one hand the community either grows gradually, if the distance to the river is small and the economic benefit of proximity is maximized, or on the other hand is abruptly decreased, in case of flood damage.
- Technology: this can be seen as how the level of protection is influenced by time. Decision-makers will foster the raising of levees if the damage caused by flooding exceeds the costs for the planned structural measures. This happens shortly after the damaging event because the awareness to flood risk is still high. On the contrary technical measures will gradually decay over time, or also happen to fail depending on the material and technology used when built (Michelazzo et al. 2016).

- Society: the awareness of flood risk varies in time. Psychological shocks experienced in flood events raise the awareness for vulnerability. However, if a person has not experienced a damaging event in his or her lifetime, or if there is no personal connection to someone being at risk (i.e. if parents tell stories of how they experienced events which triggered psychological shocks or created monetary damage) the awareness for being vulnerable decreases over time and the experience will be forgotten. Scolobig et al. (2012) interviewed 400 people living in flood prone areas and found out that for about 90% of the respondents who have experienced a damaging flood event the motive for the awareness of risk was their memory of the experience. For only about 5% of the people interviewed, "official information" also creates risk awareness. In general though, according to Kasperson et al. (1996), most people get the information and learn about floods from the media, rather than through personal experience (Gober et al. 2015).

At this point however, it is important to say that Di Baldassarre et al. (2013) note that "the high complexity of hydrological, economical, political, technological and social processes is simplified as much as possible. […] This conceptualisation should be considered as an educated hypothesis of how human flood-systems work in a generalised way, rather than a predictive tool for a particular location. This conceptualisation enables the unravelling of feedbacks between hydrological and social processes" (p. 3301). Gober et al. (2015) believe that the proposed conceptualisation has heuristic value, although it should be considered that human activities have greater effects than the ones of levees and dams, mentioned in the model of the types of five processes. Generally speaking, to capture human behaviour in a model is delicate because it can be very unpredictable and therefore difficult to incorporate (Troy et al. 2015). Furthermore, governmental, economic and social processes are definitely more complex in reality than considered by the conceptualisation and types of floods and frequencies differ for nearly every flood plain (Fuchs et al. 2017). Though it is mentioned by Di Baldassarre et al. (2013) that "this lumped model neglects the heterogeneity of hydrological, economical, technological and political processes" (p. 3301). Nevertheless, this simulation is an important first step into the right direction, so more empirical research can be carried out in the field of socio-hydrology in flood risk management (Gober et al. 2015; Loucks. 2015).

Moreover, the model of Di Baldassarre et al. (2013) assumes that the resilience of a community is built on social memory and the time that has passed since the last flood event. This is criticized by Gober et al. (2015) who propose that social resilience is linked with processes like togetherness and being part of a social network, having the capability of learning from others, and standing up for collective action. In addition, preparedness is one factor of resilience which must not be neglected. Policy adaptation is another important factor in creating a resilient community against flood risk (Gober et al. 2015). Experience and gained knowledge must be accounted for in formal decision making in order for a society to remain (Fuchs et al. 2017). Social memory is not the only way how risk is perceived. The way institutions handle risk is important for the reaction how a biophysical hazard is dealt with in a community. At this point should be emphasized again that the model by Di Baldassarre et al. (2013) is only an oversimplified version of the reality and that social processes, besides hydrological, economical, political and technological factors are more heterogenous than portrayed.

Figure 3 is a visualization of how the five types of processes (politics, economy, hydrology, society and technology) defined by Di Baldassarre et al. (2013) are interlinked plus how they influence each other. Interlinkages are indicated by the continuous thin arrows. The dashed thin arrows show control mechanisms where the economy may control politics as well as the technological level. Technology influences the way how flooding is experienced by the affected parties. When flooding occurs, the interlinkages change, which in figure 3 is illustrated by the thick arrows. The sudden event of flooding changes the way how the economy, society and technology co-evolve. A change in technology, by, for instance putting up or altering the size of levees or dams, impacts both the economy and society. Wealth is decreased by raising levees and dams as money needs to be invested, meaning that less money is available for other sectors. Moreover, the awareness of floods in people decreases with the presence of technical structures. This can be ascribed to the “levee effect”, which will be mentioned again in section 3.4.3 (Di Baldassarre et al. 2015; White. 1945). When levees are built the frequency of flooding is reduced so people feel protected and save against all flood events and other measures of prevention or preparedness are no longer considered necessary (Jüpner. 2018). In fact however, the levee increases the vulnerability of people for events with a low frequency and high magnitude (White. 1945).

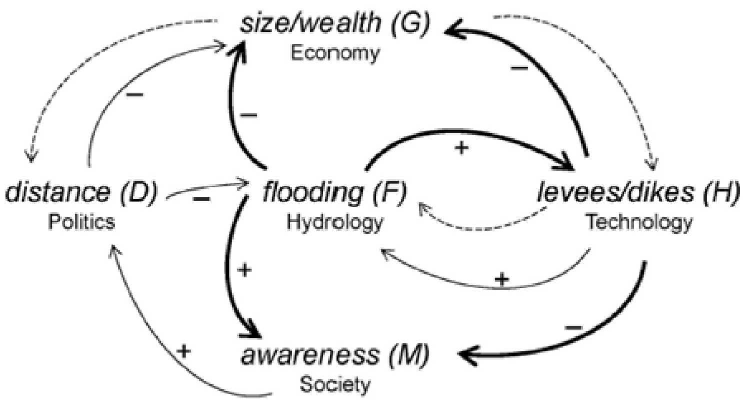


Figure 3: Interlinkages of the five processes of socio-hydrology (adapted from Di Baldassarre et al. 2013, p. 3298).

Socio-hydrology is called a scientific discipline that generates the study of real-world systems in several sectors, for example climate, ecological degradation, human management and socio-economic status. Therefore, for it to be successful, a wide range of scientists and experts in these fields need to work together and contribute in order to generate feasible solutions to the water sustainability challenges the globe is now facing (Sivapalan et al. 2014).

Furthermore, this newly created science of predicting possible trajectories of the system dynamics on a long-term basis meets the approval of governments as they are confronted with making long-term, strategic decisions. However, in the future even longer timescales and dynamics which have not yet been considered, will be part of socio-hydrology (Sivapalan et al. 2012).

## 2.4 Summary of chapter 2

Hydrology has a long history. First evidence of water resources management found, is dating back to at least 4000 B.C. Different kinds of water supply systems and flood management structures were built by early civilizations in Mesopotamia, Egypt, India as well as China, where some of the constructions are still existent today.

Although structures have been built in early times, the term "water resources management" came up a lot later. Namely, when in the mid - 20th century a global water shortage occurred and when after the "green revolution" in the 1960´s, the UNESCO first became aware that a reasonable way of using water resources must be found, both in developed and developing countries. This drew attention to a systematic study of water and with it more institutions became interested in the preservation of global water in contrast to degrading it.

In the 1990´s, awareness in addition to environmental protection, public participation and sustainability was created, so a shift in thinking took place. Water resources management was then started to be practiced in a decentralized decision-making process, in contrast to the previous top-down manner. This was all adding up to the “comprehensive way of management”, as the newly developed integrated management of water was called.

To point out the importance of water, it´s preservation and sustainable management, the UNESCO and the international Association of Hydrological Sciences (IAHS), another scientific non-profit international non-governmental organization, both created international initiatives dedicated to water research and the development of water sciences, which were important for the development of socio-hydrology.

Since the early 2000´s scientists became more and more interested in studying the interaction between humans and water systems, due to the fact that these two components are most important in sustainable water use and sustainable human development. Interdisciplinarity became more popular in water sciences and led to the establishment of “socio-hydrology” in 2012. Bi-directional-, two-way interaction and the feedbacks created by the interplay of humans and water, plus longer time scales are considered by this new science of people and water.

# Chapter 3

# Natural hazard problems and adaptation

In ancient times floods were seen as precious and vital because of their deposits which were important for the re-fertilization of the soil and subsequent plant growth. Biswas (1970) states that people in ancient Egypt even celebrated the annual inundation of the Nile. They were looking forward to the life-giving water to arrive; raising hopes for a good crop the upcoming year (Biswas. 1970).

Since the world´s population is growing fast there is an increasing demand for space to settle. Therefore, more often areas which have been avoided for building in the past and were meant to be natural areas and in a lot of cases served as natural hazard mitigation, are being expanded and "people move to new areas" (Raschky. 2008, p. 627). As a matter of fact, with increased population growth a shift in the spatial distribution of people is witnessed. Increasingly more hazardous spaces are being populated due to different reasons; either scarce resources are exploited in this area (e.g. natural or agricultural resources), there is not enough space and residential areas are extended or, people want to increase their standard of living and therefore move to less populated, but potentially hazardous places. Therefore, protective structures against natural hazards (e.g. floods, but also avalanches and landslides) need to be built so people can inhabit these areas without constantly being at risk (Aulitzky. 1994; Cannon. 1994; Raschky. 2008).

The increase in the world's population is directly linked to resource use per person, waste production and the degradation of the environment (The National Academics of Sciences, Engineering, Medicine. 1993). On the one hand this increase in the number of people and their activity strongly affects the environment, but on the other hand nature and our surrounding influence growing societies too. Hence, human activities and environmental settings need to be regarded collectively instead of being handled as separate spheres (Cannon. 1994; Fuchs. 2009). As Raschky (2008) states, the number of natural events with dramatic outcomes has highly increased since the 1960s and economic losses as well as "the monetary damage caused by floods has been increasing exponentially" (Grothmann et al. 2006, p.102). The Intergovernmental Panel on Climate Change (IPCC) even suggests that on a world-wide basis the economic losses are still on the rise and that in the near future this trend is going to continue (Raschky. 2008).

Talking about extremes, natural events can either happen without anybody noticing it or they can generate devastating outcomes, plus there is a wide range of options that lie in between. This chapter focuses principally on flood events. Cannon (1994) shows that disasters are not natural, but hazards are, and how important it is for scientists, engineers and everyone else, to encourage the interconnectedness between the relationship of humans, the natural hazard and the disastrous event. Furthermore, Raschky (2008) says, that natural hazards are specifically a function between the natural process and any sort of human activity, and that increasing numbers of people start seeing this interconnection.

Generally speaking, the basis of hazard reduction is mitigation and preparedness. However, only concentrating on mitigating the hazard and preparedness (which is mainly related to technical measures) can lead to inappropriate and potentially dangerous situations. Not only technical interventions are important, but economic and social systems also need to be considered holistically, not only by public authorities, when working in the field of natural hazard reduction (Cannon. 1994).

## 3.1 Vulnerability to natural hazards

Capitalism in its expansion throughout the world has fostered specific forms of vulnerability, in both first and third world countries – even though, no political system can avoid disasters from happening and each form of governance creates new, different forms of vulnerability. However, vulnerability as it is commonly understood and discussed here is related to “consequences of a natural hazard” (Fuchs et al. 2007, p. 495).

It is evident that natural hazards are increasing in frequency and in some places of the world nowadays natural disasters are becoming to be “normality” rather than happening as rare incidents. It is therefore important to identify by what factors a society´s vulnerability is determined (Raschky. 2008). Work from 1976 and 1979 by O´Keefe and Cannon, in vulnerability analysis, can be seen as the basis for the development of the vulnerability concept. In the 1970s it is the first time that the term ‘vulnerability’ is used in natural disasters management (Wisner et al. 1994). Since then, different types of disaster management and diverse ways of assessing physical, social, economic and attitudinal vulnerability have developed (Fuchs. 2009; M&E Studies. 2015). Social sciences, natural sciences, engineers or politicians commonly approach diverse issues when using the term vulnerability (Fuchs. 2009). This underlines the idea that all systems are vulnerable to disasters in their own ways (Cannon. 1994).

### 3.1.1 Defining vulnerability

So, what does vulnerability mean? With little consistency, the definitions range from “the reduced capacity to ´adapt to´, or adjust to, a determined set of environmental circumstances" (Cardona. 2004, p.37), to more technical descriptions like "vulnerability is usually considered as a function of a given intensity of a process and is defined as the expected degree of loss for an element at risk as a consequence of a certain event" (Fuchs et al. 2007, p. 496) or even "Vulnerability = Hazard – Coping" (Alwang et al. 2001, p. 20).

In the process of understanding what vulnerability describes, Cannon (1994) says that the environment itself is a "social construction", whereas Fuchs (2009) writing about mountain hazards specifically, argues that it is the hazard (seen as a "stressor") which is a "social construction". This is argued the following way: opportunities and risks vary in characteristics depending on the demands society puts on nature as well as how nature variously impacts all types of social systems. With diverse exposure of social units, different coping capacities need to be applied. Because of the socio-economic systems, people´s access to opportunities and their exposure to risks are unequal. Social systems themselves generate inequality in the exposure to risk through making some societies more prone to natural hazards than others. Therefore, it can be said that hazards are not natural because the impact always depends on the degree of vulnerability of the society or region where it strikes (Cannon. 1994; Raschky. 2008; Wisner et al. 1994).

Generally, the term vulnerability is widely used in all different kinds of scientific areas. Fuchs et al. (2011) write that the term vulnerability is gaining more popularity, mainly because it is such a fuzzy term that it can be applied to various scientific disciplines. Natural scientists, social scientists, engineers and economists, as well as many others working with this term, create a multiplicity of different definitions and concepts fitting to their topic, which can be confusing especially for laypeople (Fuchs et al. 2011).

### 3.1.2 Vulnerability as a social causation

Inequality factors in a society mostly originate from the principal systems of power which are operating in all societies; class, gender, occupation, age, ethnicity, health status and extent of social networks (Cannon. 1994; Wisner et al. 1994). In order to grasp the relationship between nature and humans it needs to be understood how human systems place people in relation to each other. "The main concept by which this 'social causation' is explained is vulnerability, which is a measure of the degree and type of exposure to risk generated by different societies in relation to hazards" (Cannon. 1994, p.16).

Wisner et al. (1994) say that "disasters are a complex mix of natural hazards and human action" (p. 5). Through negligence or inappropriate response, and an accumulation of value behind levees which can be observed happening at most rivers in Europe, social systems have already made disasters out of situations which could have had less serious outcomes otherwise. The smaller the expectation of a flood is, the more severe its impact will be

(Hartmann. 2011). Growing awareness has led to an increased understanding that for a natural hazard to become a disaster it needs to encounter people who are vulnerable. "Therefore, it is essential to identify the factors that determine a society´s vulnerability against natural hazards" (Raschky. 2008, p. 627). Academics and development practitioners have shown great interest in the use of various concepts of vulnerability in the last decades, which is indicative for how disasters are the product of political and economic factors.

This involvement of new ideas creates a new international framework for the avoidance of natural disasters. One stated reason for this shift in interest which has led to different vulnerability concepts, is the trend of increasing awareness of the development problems and the challenges for improving people´s living standards in third world countries. In addition, what creates awareness is the fact that the human destruction of the environment is more and more recognized. Increasing amounts of people see a connection between economic growth and social misery, plus it is realized that famines in less developed countries are no longer only resulting from a lack of rain or food but are rather caused by economic and political factors (Clark et al. 2017; Raschky. 2008; Raworth. 2017; Wisner et al. 1994).

A downside of this new awareness is that there is still a lack of connecting phenomena with each other; it is not being looked at from a holistic point of view, which would be crucial in interconnected topics like this. For example, in the 1990s during the "International Decade for Natural Disaster Reduction" even the United Nations did not distinguish between natural and human induced disasters, and it was believed that technical, structural measurements are the only way to keep nature under control (Cannon. 1994). The social aspect of natural disasters has not yet gained attention. Stakeholders in this case, did not see how important it is to incorporate other aspects as well. At this point now, it is becoming obvious for an increasing number of people that the former way of thinking was narrow-minded and that a wider range of characteristics play a part in problems arising from natural hazards. Besides structural measures, there are other ways of mitigating or coping with natural events which are more diverse and differentiate between the individual characteristics of a certain area, as is talked about in section 3.3.

### 3.1.3 Aspects of vulnerability

Cannon (1994) comes up with three aspects of vulnerability: the degree of resilience, health and the degree of preparedness. The degree of resilience is explained as "the particular livelihood system of an individual or group, and their capacity for resisting the impact of a hazard" (p.19). Included in this explanation is the ability for recovery. The second aspect, health, also talks about robustness in recovery, whereas the third aspect mentioned, the degree of preparedness, includes technical measures for example warning systems, land zoning or preparedness planning, but also measures like insurance against natural hazards. As it is obvious that livelihoods are more stable in economically more developed countries than in economically less developed countries, health, preparedness as well as post-event aid are more sophisticated, so individuals in first world countries are less vulnerable (Cannon. 1994). The differentiation between economically wealthy and economically poorer countries is talked about in more detail in the next section.

Self-protection is also incorporated in these aspects of vulnerability and for a better understanding of how important it is to protect oneself, the following example is presented: For the construction of a stable house in a flood prone area, a certain amount of money is needed. In order to be able to afford a high, or at least adequate protection level, a job with a sufficient salary is required. The level of protection can be explained as being related to income and savings capacity, meaning the less money an individual is able to provide, in most cases the lower the level of protection is.

Moreover, not only does a variability in social vulnerability exist, but there are also great differences regarding the hazard. Some societies may be devastated by a flood but not by a hurricane, others by a hurricane but not by floods. The extent of vulnerability depends on the location of the affected persons and their position in society (Cannon. 1994).

Focusing on the dissimilar distribution of people in societies it can be clearly seen that disasters are not natural. As Cannon (1994, p. 19) states: "natural events are natural but they become a disaster when they happen to people who are put at risk because of their vulnerability." Disasters happen when vulnerable people are affected and both extent and type of vulnerability are created by political and economic systems (Raschky. 2008).

For identifying the various levels of vulnerability, some examples are listed here: technologies are introduced in some regions but not in others; research topics are more relevant in certain places but not even considered elsewhere; some countries spend more money on disaster prevention and mitigation than others. The different political and economic systems should be analysed with an emphasis on how the societal structure determines the severity in which a hazard presumably affects it (Cannon. 1994).

### 3.1.4 Processes creating vulnerability

National and international level processes which create people´s vulnerability are similar to those creating differences in wealth, power and control over resources. This political and economic separation of people living in a society is also acknowledged in the vulnerability concept – some people´s lives are safer than others´. This however, does not apply only to economically more or economically less developed countries, but this differentiation can be seen within both. Some people who are discriminated against (for various reasons) are very often placed in areas where hazards are more likely to strike; they are marginalized. To give some extreme examples, in Bangladesh, those individuals who cannot afford a wealthy life (from a monetary point of view) live in flood prone areas; in Rio de Janeiro poorer people are located on unstable slopes at the border of the city (Cannon. 1994). Raschky (2008) gives a more generalized explanation, saying that people who live in countries with a higher economic income or education, experience less harm from catastrophic events than people who live in countries with a smaller economy and lower levels of education. “Economic development and losses from disasters are inversely correlated” (p. 628).

In Austria, Fuchs (2009) argues that inequalities in society, low levels of education or gender do not set the conditions for vulnerability to natural hazards. Institutional parameters created from land use regulations, risk transfer mechanisms, desires of individuals and expected economic benefit from a governmental point of view “can be used to reduce social vulnerability to natural hazards” (p. 347). What can be done to reduce the vulnerability of a society is discussed in the next section.

### 3.1.5 Reducing vulnerability

Since these different levels of vulnerability exist among human societies, in order to reduce vulnerability even in wealthy countries, Cannon (1994) suggests the application of some kind of analysis to detect which groups of people are more vulnerable. Significant indicators of the diverse vulnerabilities to hazards, listed by different authors, and which were already mentioned in section 3.1.2. are class, gender and ethnicity.

The extent of vulnerability can be reduced with either an increase in resilience and coping capacity or by modifying the hazard. By engineers, who also integrate social aspects in hazard mitigation, it is criticized that these approaches focused on modifying the hazard are most often hazard-centred rather than people-centred. Preparedness and mitigation should always aim at reducing peoples’ vulnerability. In some places, especially in societies in Europe, this is done by the use of multiple compensation mechanisms. These take the form of, for example, building regulations, governmental compensation, private donations or through activities of non-governmental organizations (NGOs). Societies in Europe have considerably lower levels of vulnerability since these compensation mechanisms are in place (Fuchs. 2009). Cannon (1994) argues that merely relying on scientific knowledge and technical means of hazard mitigation can be dangerous, since a favourable reduction in hazards can only be reached if other components of the vulnerability profile are also changed for the better.

Basically, there is always the chance that new forms of vulnerability arise. To illustrate, Cannon (1994) mentions capitalism as it has generated new forms of vulnerability while spreading around the globe. Third world socialist systems have created their own vulnerability patterns, e.g. the Chinese famine from 1959-1961, where new kinds of vulnerability arose due to new unsuitable forms of collective ownership and work remuneration in the communes. However, there are also positive examples of societies experiencing a decrease in vulnerability. Cuba for example, has a better record in handling common hazards, namely cyclones, than neighbouring Haiti (Cannon. 1994).

To Cannon (1994) it is important to create a better understanding for disasters and he aims for the development of better policy interventions with the help of a vulnerability analysis framework. His and other papers on this topic illustrate well how broad and complex the topic of hazard reduction is and how many different stakeholders should be involved for it to keep the damages as low as possible.

## 3.2 Self-responsibility and adaptation

Holub et al. (2009) comment, that the "provision of protection against natural hazards is commonly regarded as a governmental duty" (p. 529). It has been observed that people living in potential dangerous areas very often believe that they do not have to implement measures of any kind which could decrease property damage, injury or even death from natural hazards (Grothmann et al. 2006). Either the government will take care of that, insurance will cover the damage or people will be assisted with financial relief from a fund, as it is done in Austria (for more detail about funds in Austria see sections 6.8.2 and 6.8.3). These existing funds however can lead to the phenomenon already mentioned, of underinsurance or even non-insurance (Raschky. 2008). Besides insurance cover, catastrophe bonds can also be a transfer of risk, which has turned out to be a common mechanism in risk management of natural hazards (Fuchs. 2009; Holub et al. 2009; Nachtnebel et al. 2009). This does not only lead to a denial of self-responsibility on a personal level but additionally creates a trend of decreasing willingness to invest private money for protection purposes. Looking for a scapegoat and blaming political institutions has become quite popular in everyday life. Raising awareness and encouraging people in hazardous areas to act responsibly, install local (object) protection measures or apply retrofitting should be reinforced in the future to minimize the impact for all stakeholders (Grothmann et al. 2006; Holub et al. 2009; Nachtnebel et al. 2009).

Grothmann et al. (2006) even state that in Germany, residents' self-protective behaviour can reduce monetary flood damage by up to 80%, including a lower requirement for public risk management. Building disaster-resilient communities is a future goal in Austria which can be achieved through land-use regulations, risk transfer and informing the public.

Risk maps compiled by experts are distributed to affected communities. On the one hand being informed is positive for residents, but on the other hand this form of creating awareness in people is only a one-way communication. Often end users have a diverging perception of risk or they do not fully understand what these maps are meant to tell them, so in order for the information to reach them fully a feedback loop has to be established.

Grothmann et al. (2006) describe three factors that determine vulnerability and extent of flood damage of social systems, for example cities: exposure to floods, sensitivity to flooding and adaptation. Indicators like flood frequency, water level, flow velocity and duration of the flood can be used to determine the first factor, namely exposure to floods. Sensitivity to flooding, the second factor, can be captured with the help of population density, economic values or building structure. Adaptation, as a last determinant, is the one given attention to as follows. To capture adaptation, the ability to avoid potential damage from flooding is measured.

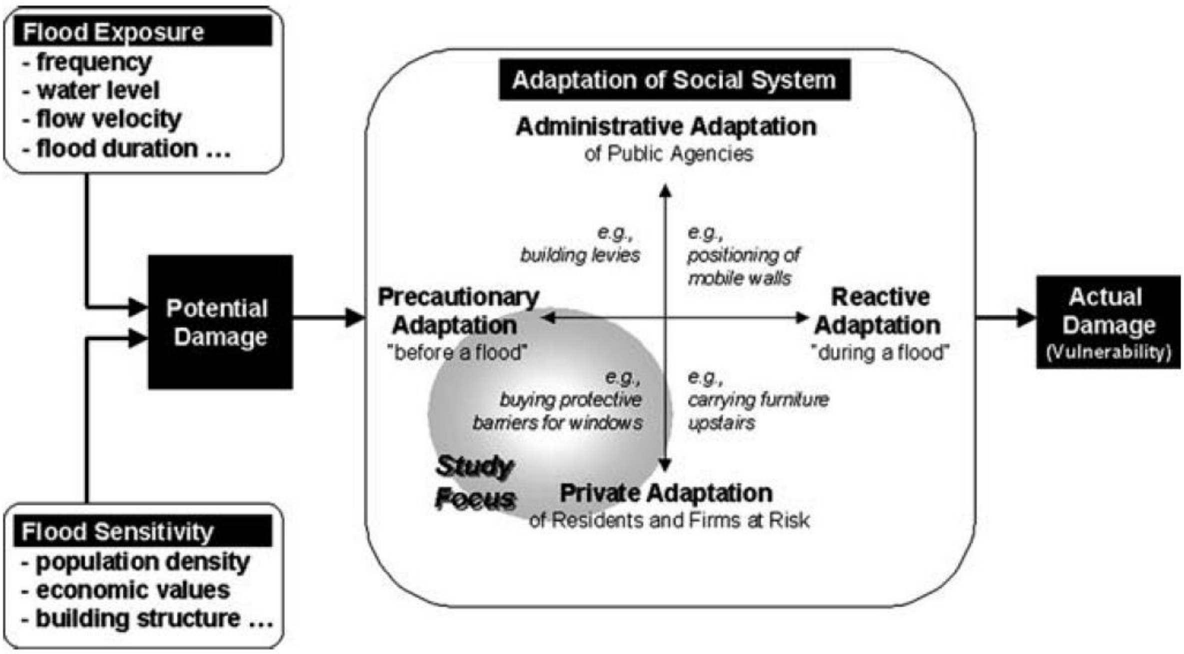


Figure 4: Main determinants of flood damage and vulnerability (from Grothmann et al. 2006, p. 102).

As can be viewed in figure 4, there are diverse forms of adaptation suggested by Grothmann et al. (2006). There is a need to differentiate between administrative and private adaptation, as well as between precautionary and reactive adaptation. Public agencies may take precautionary measures (e.g. building levees) or use mobile protection walls as a form of reactive adaptation. Individuals, as ways of private adaptation, can install local object protection measures in various forms. For instance, protective barriers for windows can be bought in order to keep the water out of their house, or furniture is carried upstairs as an immediate reaction during the flood. There are numerous other examples of adapting buildings to flood events listed in the papers of Grothmann et al. (2006) or Kreibich et al. (2005) and two examples of mobile flood protection walls can be seen in figures 5 and 6. A few other options for adaptation are listed here: waterproof sealing for windows and doors, fortification, flood adapted interior fitting, structural changes to homes (e.g. installation of sauna, high tech hobby room, or energy and water installations in the top floors of the building instead of downstairs in the cellar), safeguarding of hazardous substances (e.g. small sewage treatment plants or gas or district heating must have water tight closures to avoid fuel contamination), permanent or mobile water barriers, installing backwater valves for sanitation where there is a risk of backwater entering the house from the sewage network, and so forth.

Figure 5: Construction of mobile water barriers for a house along the river Danube in Schärding, Upper Austria (from Habersack et al. 2015, p. 45).

Figure 6: Mobile protection walls along the river Danube in Krems, Lower Austria (from Habersack et al. 2015, p. 45).

There are various ways of adapting to flood events and strategies differ between countries, societies and on a smaller scale also within communities and individuals (Consoer et al. 2018). In the following sections a few more ways of coping with natural hazards are mentioned.

### 3.2.1 Risk perception

The way that risk is perceived by individuals varies greatly. So do the adaptation strategies which are strongly dependent on if and how past events have been experienced, on the socio-economic situation and cognitive factors, like behaviour in decision-making processes (Siegrist et al. 2006). Risk situations are a "very complex framework with multiple influencing factors" (Fuchs et al. 2017, p. 3185). Variations in the discernment of risk can be seen within a society, certainly between rural and urban areas, plus evidence shows differences within sub-regions as well (Fuchs et al. 2017).

Factors that influence both perceived risk and prevention behaviour were examined by Siegrist et al. (2006). The authors state that several other studies also support their idea that experiences of natural hazards play an important role in how future hazards are perceived and to what extent prevention is encouraged. If damage from a natural event was part of an individual´s past, the tendency to purchase insurance or take measures against natural hazards was higher compared to someone who had not experienced losses of the same kind. Although the income of a person plus the price of the insurance are important factors, the emotional reaction to (not only) risky situations also has a strong effect on motivating prevention behaviour. Furthermore, being part of cleaning flood damages has a positive impact, whereas personal antipathy towards insurance has a negative influence on prevention behaviour (Siegrist et al. 2006).

### 3.2.2 Structural and non-structural adaptation

Early works, such as White (1945), mention adjustments to floods subdivided into structural or otherwise emergency measures, land-use, insurance and relief. The latter three measures, amongst others, are now known as non-structural adjustments. Today, seventy years later, non-structural measures play a central role in the contemporary management of natural hazards (Fuchs. 2009). However, it needs to be pointed out, how important the tailoring of policies and measures is for every catchment, since each of them has their unique characteristics to be considered (Consoer et al. 2018). For further details on adaptation measures see the introduction into section 3.2.

### 3.2.3 Adaptation and levee effect

Di Baldassarre et al. (2015) describe two types of dynamics in natural hazards management which are of great importance: the adaptation effect and the so-called levee effect. The adaptation effect explains how people adapt to risk situations; if a flood is happening shortly after a similar event, the psychological, economic or social effects are less. For the levee effect it is exactly the other way around; people living behind dams or levees tend to have an increased vulnerability if a flood happens that exceeds the protective structures. Societies are used to the fact that water is kept away from their houses and values by the existing structure. So, in case a flood event exceeds the levels of the calculated magnitude that the structures can withstand, people are surprised and even hit harder. In this case the flood comes unexpected which makes them even more vulnerable (Jüpner. 2018; Nachtnebel et al. 2009; White. 1945).

### 3.2.4 “Living with floods” versus “fighting floods” policies

Two different prototypes of floodplain management are presented by Di Baldassarre et al. (2015): on the one hand green societies exist with a “living with floods” policy whereas technological societies tend to follow a “fighting floods” policy.

In the Netherlands, for example, centuries ago people started the process of reclaiming and draining land. As a protection measure against floods they had to raise dams, since two thirds of the total country lie below sea-level (Brouwer et al. 2004). Nonetheless in areas where it is easily possible, the traditional policies nowadays are replaced or supported by long term measures, which are more sustainable. Brouwer et al. (2004) state in their paper that “learning to live with floods through land use changes and floodplain restoration is also believed to increase public awareness and appreciation of water system dynamics and resilience, and even result in a reduction of future damage by changing the nature of economic activities in places at high risk of flooding” (p. 2). This new policy has been introduced in the Netherlands in 1998, and according to Brouwer et al. (2004) who did a multi-criteria analysis on this topic, it is preferred over the traditional method of dam strengthening.

## 3.3 Summary of chapter 3

Problems arising from natural hazards can be very diverse, affecting different kinds of people differently. Different systems are vulnerable to natural events in different forms. Vulnerability, in its various characteristics, is a main factor for influencing the nature and the extent of damage caused by natural hazards. It is important to determine the vulnerability of a society, since natural events are increasing in frequency and magnitude, and in order to create disaster resilient communities, one needs to know which areas need adaption or in what ways mitigating a hazard can be achieved.

Internationally the interaction between humans and nature has gained more attention since the 1970s when the term vulnerability was first introduced in natural sciences. Although this growth in awareness is a first step into the right direction, it is crucial that natural hazards impacting human systems are not yet looked at from a holistic point of view.

Since about 500 years ago, a number of tools have been developed to mitigate or prevent losses from natural events. Structural measures were, and still are, the most favourable since it is easier to build a structure than to foster behavioural changes in a society. As a lot of different problems exist, also a lot of different adaptation strategies have been found so far in natural hazard management. It is distinguished between administrative and private adaptation, as well as between precautionary and reactive adaptation. Precautionary measures, either being structural or non-structural, have significant potential in the reduction of flood damage. In addition to these strategies, this chapter also discusses the way that risk perception influences protective behaviour towards natural hazards, plus the adaptation and levee effects, and policies of living with floods or fighting floods.

# Chapter 4

# Upstream and Downstream Co-operation

In flood risk management, structural measures need to be taken upstream of the exposed object or area to be effective and to fulfil their protective function. Therefore, ideally, in the management of a river, stakeholders and actors of the whole catchment are involved in the decision-making, as well as in the management process, so everyone can decide what is best for all affected parties (Johnson. 2002; Margerum. 1995; Medema et al. 2016; O`Neill Karen. 2005). This is the reason why co-operation between upstream and downstream is of great importance for a successful management strategy (Thaler. 2014). Not only is it important on a catchment scale, but also on larger spatial scales. An example is the Danube river basin, which is shared between 14 contracting parties and the European Union. Basin – wide collaboration between the parties is necessary to ensure that this mostly international river basin is kept clean, healthy and safe (International Commission for the Protection of the Danube River. 2016). The focus of this chapter, however, lies on the catchment scale approaches.

As simple as it sounds, as Seher et al. (2016) state, in reality it seems difficult to create inter-local partnership approaches, since there are a variety of difficulties to face. Conflicts seem to be inevitable because seldom a balanced win-win situation can be reached which satisfies all the parties. Very often it is the case that the upstream party does not see an advantage in spending money on measures which mainly benefit the downstream party. In return, the downstream municipality is very often not willing to compensate the upstream municipality (Thaler. 2014).

Due to the existence of these problems, it is even more important to establish arrangements between the upstream and the downstream communities. These can be fundamentally successful if not only the shared resources are managed in a way that everyone involved agrees, but also the relationship between the affected local authorities and the stakeholders is cultivated (Margerum. 1995).

## 4.1 Partnership approaches in flood risk management

*"The key point is the intended outcome of the partnership"*

(Thaler. 2014, p. 1019)

### 4.1.1 Why are partnership arrangements needed in flood risk management?

Thaler (2014) discusses different drivers for the creation of various forms of co-operation in flood risk management, which are listed below. The sharing of financial- and risk burdens is one key aspect for the creation of a partnership. In order for the partnership arrangement to be successfully initiated, the baseline is the involvement of all stakeholders and actors in the planning process.

- Exceptional events – in most cases a recently experienced crisis is the "eye-opener" and very often sets the idea of implementing new policies or to put new instruments in motion. Furthermore, private businesses have a strong influence on local authorities, as they are important to the region in an economic sense. Therefore, if they expect their businesses to be safe from exceptional events and have great interest in the implementation of flood protection measures, they probably have higher leverage on authorities than other actors in the region. This however, also depends on the region because every case is different. In addition, it seems that local authorities have a higher willingness to be part of the co-operation if private actors contribute.

- Local/ regional leadership on site – the Federal Water Engineering Administration and the Service on Torrent and Avalanche Control play the major role in the prevention of flood risk in Austria. However, it is important to have people in charge who know the region, contribute on site and follow the regional or national leadership (which exists in the form of the two leading authorities mentioned).

- Gaining benefits – in most cases the expectation of maximizing the community benefit is the main reason why a community joins a co-operation.

- Fair risk-sharing – in Austria, most co-operations have introduced a financial contribution based on solidarity. The reason is that a safety benefit that has to be transferred from the upstream to the downstream community. To balance the costs of both communities, the "solidarity financial contribution" as it is called, was put up. This means that the downstream parties pay more because they have a greater benefit from upstream measures. This is how costs are "balanced", however a fair division of the expenses is difficult to reach.

A shared vision – having a common vision of managing flood risks and following a common goal of why flood risk management in the proposed context is important, is another important driver for the co-operation of municipalities. Keeping the different stakeholders together on the same track can be a difficult task since interests can deviate from each other or misunderstandings can occur. At this point, the regional and national authorities play an important role in motivating actors to co-operate, although this can be very difficult, and the involvement of many actors poses the opportunity of failure. Still there is a chance of even greater success if things work out for everyone as expected.

Face to face interaction, a strong legal basis, plus meetings on a regular basis where people can exchange ideas and values are important determinants for a successful co-operation (Margerum. 1995; Medema et al. 2016).

The main purpose of inter-local co-operation is the transfer of risk from urban areas (which from an economic point of view are areas of high vulnerability and value) to areas of lower value such as low intensity agricultural areas. Landowners will therefore be compensated in various ways to provide land to flood protection measures (Thaler. 2014). This is the reason why landowners play a very important role in flood risk management strategies. If the suitable land is not provided, without them, certain hazard management approaches cannot be implemented. “In implementing non-structural flood protection measures on private property, landowners are providing public flood mitigation benefits sometimes at the expense of their ability to use that property” (Milman et al. 2017, p. 35). Apart from that, flood risk management strategies influence landowners and the approach towards their land, and vice versa; landowners also have an influence on coping mechanisms towards excess water. On the one hand understanding their perspectives can minimize arising problems, for instance political conflicts, and on the other hand, it could lead to a greater public support of flood risk measures (Becker et al. 2012; Milman et al. 2017).

### 4.1.2 Different forms of relationships in flood risk management

As shown in table 3, there are three different forms of relationship in flood risk management listed by Thaler (2014). A partnership based on competition only lasts for a short time. The intention is to gain maximum benefits with a focus on oneself and a low commitment towards other actors involved. Means of protection are most likely only considered locally without any intentions of setting further measures or being involved in catchment-wide strategies. Secondly, egoistic forms with a modest commitment have a medium longevity. The key objective in the egoistic form is to gain absolute advantages under consideration of the relative advantages. As long as the costs and preferences for a catchment-wide management system are higher than the local measures, the co-operation is supported. In egoistic approaches, Thaler (2014) adds that there are considerable differences in the implication for inter-local flood risk management strategies between economically rich and poor communities. The third form of relationship identified by Thaler (2014) is co-operation.

This partnership approach seems to be the most enduring from all three approaches mentioned. With the focus on a long time-framework, the commitment is strong, intending to gain absolute advantages while aiming at bringing all stakeholders and actors together in a co-operation. Implication of an inter-local flood risk management strategy is the aim of the reduction of negative externalities.

| | Time framework | Commitment | Short description | Implications for inter-local flood risk management strategies |
|---|---|---|---|---|
| Competition | Short | Low | Key objective is to gain relative advantages instead of long-term relationship | Local protection schemes without catchment-wide management actions |
| Egoistic | Medium | Modest | Key objective is to gain absolute advantages, under consideration of the relative advantages | Catchment-wide management system, as long as costs and preferences are higher than local protection measures; very different between rich and poor communities |
| Co-operation | Long | Strong | Key objective is to gain absolute advantages, with the aim of co-production between actors and stakeholders | Inter-local flood risk management, with the aim of reducing negative externalities |

Table 3: Different forms of relationships in flood risk management (from Thaler. 2014, p. 1019).

### 4.1.3 Proximity in flood risk management

The success of a co-operation also depends very much on the distance between the actors – not only the spatial distance but also the social/relational distance. If the actors and stakeholders foster collaboration, they tend to feel closer to each other; like being friends or even family, they will probably engage more than if they are not familiar with each other. Trust is very important in successful inter-local co-operation approaches (Fernandez-Gimenez et al. 2008; Seebauer et al. 2018). In addition to social proximity, another advantage in the management of flood risks, is keeping the spatial distance between the different parties small. This implies a large spatial proximity. If members are too separated from each other, the arrangement of personal meetings can become too complex and the possibility of losing connection and interest rises. The frequency of encounters and the personal contribution of all the stakeholders in meetings are especially influenced by spatial proximity (Thaler. 2014; Thaler et al. 2016). Furthermore, institutions and technological proximity are important factors in such partnerships. As Thaler et al. (2016, p. 843) state, “institutions are highly important for economic development, because they regulate the social and economic behaviour of individuals”. On the one hand, institutions can directly influence individuals´ behaviour, as in top-down ways of governing. On the other hand, due to individuals´ behaviour institutions are being established, in the form of a bottom-up procedure (Thaler et al. 2016). In other words, “institutions are rules or procedures that clarify how decisions are made within society” (Raschky. 2008, p. 629). Raschky (2008) also argues that in natural hazard management, countries with well-organized institutions have a greater social equality and democracy. Therefore, the resilience of these countries is higher compared to ones with weak institutions.

Common knowledge among all affected parties about technology, as well as expertise and technological experience can be combined using the expression “technological proximity”. In flood risk management, technology plays another important role, because many preventive measures (e.g. mobile protection walls), structural measures (e.g. dams) but also non-structural measures (e.g. flood warning systems) are technology based. Therefore, technological proximity is an additional factor of importance in inter-local co-operation (Thaler et al. 2016).

## 4.2 Inter-local co-operation arrangements

### 4.2.1 Requirements for successful upstream and downstream co-operation

Nachtnebel et al. (2009, p. 334) identify three requirements for successful upstream and downstream co-operation in the management of a catchment:

- Co-operation of all the stakeholders involved (local residents, planners, administration, insurance companies, emergency response team);
- Co-ordinated action among planning sectors like land development, infrastructure and natural hazard management;
- Collaboration of institutions responsible for the funding of preventive flood protection or mitigation measures as well as private precaution and damage compensation.

According to Thaler et al. (2016), one important goal in a successful partnership approach is the introduction of a common flood risk management and planning system. Nachtnebel et al.

(2009) and Thaler et al. (2016) have a very similar view of what makes a co-operation successful. All stakeholders are to be involved, are co-operating, are exchanging information about recent concepts, developments and objectives and are participating in future development. Furthermore, in an ideal case, "the partnership approach includes a full democratic and transparent system to ensure accountability and legitimacy" (Thaler et al. 2016, p. 845).

The mentioned requirements presented by Nachtnebel et al. (2009) and Thaler et al. (2016) describe a theoretical ideal and in practice only very few partnership approaches exist that can maintain their strategy and success. Very often it is the case that town planners are not effectively working together with other important sectors like water management, spatial planning or land use management and therefore they are still highly relying on technical solutions (Hartmann. 2011; Thaler et al. 2016). The purpose of any planning decision is to balance interests. This means that if all involved sectors are willing to collaborate, it is a challenge to co-ordinate them, but it would result in more resilient communities (Hartmann. 2011). In the process of fully integrating actors and stakeholders and introducing a co-operation, there are several phases which communities could go through. Inadequate or partial integration can be first steps towards reaching a successful partnership where all stakeholders are fully integrated (Thaler et al. 2016).

### 4.2.2 Challenges and barriers

Abrahamsen (2004) observed that very often the term "partnership" is used not only to describe the way in which something is mutually governed but also because it seems rhetorically innovative. In global North-South relations, economic partnerships often have been established for the purpose of providing financial aid to poor countries. After a while however, this mutual basis has very often been transformed into an economic dependency, where the poorer country has become dependent on the wealthier one – the partnership relation, which may have begun with varying degrees of collaboration, has developed into a power relation. This means that one party, usually the influential and/or wealthy one, is dominating the other. This, however, does not imply that a domination happens on purpose. Even if the intention is a good one, based on the idea of aiding others, it is the nature of the aid relationship that creates an inequality from the beginning and poses ongoing challenges for a genuine partnership (Abrahamsen. 2004).

Moreover, there is often a high competition going on between different communities in a region concerning the establishment of new business investments or the receipt of public funding. How to divide responsibilities or power, plus to agree upon further developments can pose an additional difficulty. Responding to the criticism of Abrahamsen, Hartmann (2011) presents the concept of LATER – Large Areas of Temporal Emergency Retention, which is a "partnership approach" where upstream protects downstream. LATER is examined in more detail in section 4.3.1.

### 4.2.3 Advantages and disadvantages of inter-local co-operation

In the work of Thaler (2014), the advantages as well as disadvantages of inter-local partnership approaches in flood risk management are discussed. Through a merging of available budgets for flood risk measures, each community in a co-operation can reduce local spending and save money. Moreover, financial resources and instruments for planning can be used more efficiently in a partnership scheme compared to other forms like competition or an egoistic approach, as discussed above. If spatially possible upstream communities, can offer natural retention for flood storage which works as a simpler and less costly form of flood management, instead of depending on individual solutions in each community (Margerum. 1995; Thaler. 2014).

To regional and national authorities, such an inter-local co-operation can pose exceptional circumstances due to a general risk for each party. It is not a "business as usual" situation. "Key problems are related to a fair sharing of power between the different actors" (Thaler. 2014, p. 1026). The steering groups in co-operative arrangements are very often the downstream communities which are hence, given more attention in the process of decision making than upstream parties. Furthermore, transaction costs of a co-operation are higher at the beginning of a negotiation period compared to individualized outcomes or local top-down solutions; the more actors that are involved in discussions, the more likely it will lead to longer negotiation processes and therefore involves higher costs. However, on a mid- and long-term basis, Thaler (2014) indicates that the transaction costs of a co-operation are lower than in the case of individual local authority-based approaches. In the negotiation process lies another potential risk, in addition to the just mentioned disadvantages. Especially in the initiation phase the risk of negotiations failing is relatively high and therefore also the potential for the collaboration to fail (Medema et al. 2008).

Another barrier for a successful inter-local co-operation mentioned by Thaler et al. (2016) is for instance lock-ins at local level. In the next section technological lock-ins are looked at in more detail.

### 4.2.4 Technological lock-in

*"A levee-based flood protection is technologically locked-in"*

(Hartmann. 2011, p. 90).

Technological lock-ins are situations where, in the case of flood protection, technical solutions have been built and relied on ever since people needed protection from floods. Furthermore, it could also occur that a community commits all its funding to technological solutions and is not open to other options. In many cases, since structures like levees were encouraged, spatial development has evolved trusting that these levees will be a protection against floods of any dimension for people living behind it. However, at some point of development, a society is locked-in when it believes there is no other option left but to continue to heighten already existing technical structures or to construct even more. If this is the case, the technological lock-in is tightened. This happens when even more value is accumulated behind a structure, that needs protection which leads to more levees being raised or built (Hartmann. 2010; Hartmann. 2011).

If, instead of being controlled, water is accommodated, as Wesselink (2007) suggests, it could be an opportunity out of a technological lock-in. Therefore, retention-based flood protection should be introduced, but in most cases is no longer possible due to a lack of space and money in lock-in situations (Hartmann. 2011). The construction of more levees nonetheless, is very costly too, so it is again difficult to step out of the tightening of the lock-in.

How to determine the still available natural retention capacity of a catchment is discussed as follows.

### 4.2.5 Factors determining the natural retention capacity of a catchment

Knowing the potential of the natural retention capacity in a catchment is an important precursor for upstream and downstream co-operation. Terrain, hydrography, soil and natural cover are the major players in the natural retention capacity of a catchment. All of these are retaining water up to a certain extent, and when one of the mentioned retention reservoirs is saturated, the next one will be filled. Looking at these four water reservoirs, terrain is most decisive for water retention. If the terrain is flat, more water can be held back than at steeper sites. Hydrology and the terrain are very closely connected, since water is moving with a river. In case of flooding, the wave has an asymmetrical flow and the peak of the wave is influenced by hydrology. Besides terrain and hydrography, soil is the parameter having the largest potential of retaining water. The pores in the ground are filled with water in case of rainfall until it has reached the point of saturation. The capacity of how much water can be taken up by the soil is depending on many factors, for example season and temperatures, quality of the soil, climatic conditions, the prevailing weather conditions, combustion of the ground, and many more.

When the soil is saturated, the natural cover is important as a next storage for water. It makes a large difference in water retention whether, for example, there is an agricultural field or a forest with large trees, the latter being able to take up a lot more water than small plants on a monocultural field of crops (Hartmann. 2011; Patt et al. 2011).

## 4.3 Different European approaches of flood risk management at catchment scale

Involving stakeholders of the whole catchment in flood protection nowadays is no rarity. At least three countries in Europe have developed their own concepts of how to protect the economy, people and the environment from their specific threats posed by water in various ways. In this section of chapter four, three different approaches of flood risk management are mentioned: LATER – Large Areas for Temporary Emergency Retention – a concept from Germany, the Catchment Based Approach being applied in England, and the "Room for the River"- policy from the Netherlands.

### 4.3.1 Large Area for Temporary Emergency Retention - LATER

"A responsive land policy is required to change from a levee-based flood protection to the more efficient floodplain management by LATER" (Hartmann. 2011, p. 47). LATER, short for Large Areas for Temporary Emergency Retention, is a particular kind of managing flood risks that involves retaining water and making space for water in case of extreme floods. Furthermore, this concept is dealing with the management of a floodplain not only under extreme circumstances, but also offers perspectives and opportunities for the whole catchment area (Hartmann. 2011). Hartmann (2011) talks about three management principles that are comprised in the concept of LATER:

1. upstream protects downstream;
2. viewing flood defence as an integral task, instead of it being a sectoral duty;
3. awareness of how essential it is to be prepared for extreme floods.

For the concept of LATER to be effective, an upstream-downstream co-operation is a pre-requisite. Downstream parties are very much interested in what the land upstream is used for. In order for LATER to be executed, some areas in the upstream part have to be sacrificed and provided as space to retain water if extreme flood events occur. If upstream needs to "offer" land to protect downstream parties it could create the feeling of an imbalance between them. On the other hand, without the concept of LATER being applied, it is always the downstream parties, who are providing space (and money) for protection and mitigation measures. LATER, as a certain form of flood risk management, wants to include all affected parties and divide the responsibilities between them. Ideally, there are enough areas available upstream which can be used as retention areas in case of emergency flooding (Hartmann. 2010; Hartmann. 2011). However, this is not the case in most catchment areas, because very often stretches along the rivers are already taken and land is used in whatever form. Finally, as mentioned in section 4.2.4 LATER can be an option for a society to disengage from a technological lock-in.

From a technical point of view, LATER is handled like the management of ordinary polders (Hartmann. 2011). Segeren et al. (1983) define a polder as an area of land, which permanently or on occasions is subject to high water levels, due to either surface- or ground water. According to this definition, this land becomes a polder when it is separated from the adjacent water. With this definition though, there is still enough room for interpretation; a paddy field or the floodplain of a river which is protected by a dam upstream can, per definition, be a polder. Van Schoubroeck (2010) provides a somewhat narrower definition – whereas Segeren et al. (1983) use the term for land which was separated from any kind of surrounding hydrological regime, Van Schoubroeck (2010) defines polders as land which is protected, conserved or reclaimed from the sea.

As it can be derived from the definition, the management of polders deals with the management of both land and water. The same holds true for LATER. Compared to polders, LATER is designed to mitigate outcomes of even larger flood events than polders do. Still, “the concept is different according to size, property regime, duration of use, purpose, and specific functionality of the retention areas” (Hartmann. 2011, p. 61). Designated areas for LATER provide additional space for water retention in order to delay the peak discharge and therefore keep the potential damage for downstream parties as small as possible (Hartmann. 2011).

Designating land for retention purposes is usually done by a formal plan approval. Experts first need to gather information about hydraulics, magnitude and frequency of flooding in the catchment area. This is essential to know in the evaluation process determining if LATER is even feasible. Further information gathered through these studies could for example be effects of measures on the discharge, effects on groundwater, ecological and environmental details, the level of soil contamination, just to name a few (Hartmann. 2011).

In many cases, Hartmann (2011) indicates that simply the execution of these studies can trigger rejective behaviour from landowners. This is most likely due to the fact that the immobile values of the landowners are the centre of attention when it comes to retention areas. However, since LATER is a concept for extreme flood retention only, according to Hartmann

(2011) it is possible to still access and use the land which was appointed by experts as retention areas. Several restrictions need to be accepted though. For instance, it is still possible to have settlement or business locations in LATER areas, as long as they are protected by controlled structural flood protection measures. This clearly shows that LATER is a temporal, rather than being permanent form of land use (Hartmann. 2011).

Although LATER places properties at the centre of interest and “serves for proprietors as an instrument to gain and save money” (Hartmann. 2011, p. 67), if landowners do not want to co-operate, the task of authorities involved in decision making is to provide essential information and mediate between the parties if necessary. In the end, which areas are to be chosen as effective areas for emergency retention is still a political decision (Hartmann. 2011).

### 4.3.2 The Catchment - based approach

In 2011, the government of the United Kingdom decided that locally focused decision making in the context of improving the water environment should gain more attention. “The water environment is affected by every activity that takes place on land as well as through our actions in abstracting, using and returning water to rivers, the sea and the ground” (Department for Environment, Food and Rural Affairs. 2013, p. 1). The Department for Environment, Food and Rural Affairs (2013) indicates that the United Kingdom Environment Agency and other British organisations firmly believe better co-ordinated action and engagement by all affected stakeholders in a catchment is required if the pressures placed on hydrology are to be reduced according to the European Water Framework Directive, a framework for community action in the field of water policy.

Key objectives of the Catchment Based Approach (CBA) are engagement and collaboration, plus a more transparent process in decision-making of all stakeholders at catchment level (The Rivers Trust. 2018). In the future, CBA is further expected to develop into a mechanism for strong local support, co-ordination, consensus and an efficient distribution of funds throughout the catchment. At the moment this method is still in it´s infancy, therefore the approach will most likely develop and mature over time, integrating practical downsides of the approach as they were found through ongoing evaluation carried out by the Department for Environment, Food and Rural Affairs (2013). In addition, in the interest of a higher quality water environment, ways of measuring the overall progress of the approach are being developed. Although each catchment is different and the form of collaboration between the members varies too, this framework is seen to be a document of high level which needs a well-developed structure to be applicable to different catchments (Department for Environment, Food and Rural Affairs. 2013).

Furthermore, according to the Department for Environment, Food and Rural Affairs (2013) catchment partnerships are of great importance in the CBA. These partnerships can add value to important decision-making processes at either local or sub-catchment level. Environmental problems should be translated into actions using a language that people understand and where the population can connect with issues they may recognise (as they are facing them in their surrounding). Contrary to enforcing co-operation and fostering a better understanding of the environment on a local level, the CBA also offers a way of supporting the Environment Agency in the development of a management plan at the level of River Basins required for the European Water Framework Directive (Department for Environment, Food and Rural Affairs. 2013).

### 4.3.3 The "Room for the River"- policy

The Netherlands, with a flood prone area of over 55%, have about a 1000-year history of flooding and adapting to rising water levels (and subsiding land; Klijn et al. 2012). The Dutch are well-known for developing structures for flood protection in various ways which they started in the 15th century by building dams to keep the water away from densely populated areas. The construction of a large dam (the Afsliutdijk) to prevent water from the North Sea threatening the heart of the Netherlands, was the first large-scale engineering project in the 20th century (Room for the River. n.d.b). Furthermore, new safety standards were introduced and protection measures reinforced and improved (Slomp. 2007). After these measures had been taken, the Dutch believed they were relatively safe from flooding. But in 1953 and 1955 the country was again confronted with catastrophic flood events. These events triggered awareness of the necessity of new approaches to water management, since only raising levees and increasing the height and size of protection structures is not a suitable solution (Room for the River. n.d.b). With the flood risk management policy of flood defence and relying on structural measures, the country had put itself in a situation of a technological lock-in (further discussed in section 4.2.4). Therefore, improvements in flood defence and water management structures need to be implemented and a shift to preventive water management is ongoing (Klijn et al. 2012).

In the year 2000, the Netherlands have established the "Room for the River"- policy (Hartmann. 2011). This is an integrated approach with a long-term vision with a focus on "the main objectives of flood protection, physical planning and the improvement of the overall environmental conditions" (Slomp. 2007, p. 25).

The dual goal of water safety and spatial quality makes the program unique. A special "Room for the River" quality team, consisting of five independent experts, is responsible for the improvement of spatial quality in ongoing projects. They do not create spatial plans on their own, but rather offer advice upon request and at its own initiative. After a project has been completed, the Final Spatial Quality Evaluation is also carried out by the same team (Room for the River. n.d.a).

In the Netherlands more than 30 locations were chosen to implement measures returning space to the rivers and therefore reducing flood risk. The goal is for the river be able to process more water safely (Klijn et al. 2012; World Landscape Architecture. 2017).

According to Hartmann (2011), the difference between the "Room for the River"-policy and the concept of LATER is that in the Dutch approach land is seen to be essential and "property is regarded as an obstacle for the implementation" (p.67), whereas LATER is a property-focused approach, and property lies in the centre of attention.

## 4.4 Summary of chapter 4

In the beginning of a collaboration process identifying potential areas of conflict is essential. This could include the different interests of farmers and people living in urban areas, upstream versus downstream, public and private companies' interests, high or low risk perception of affected stakeholders, and many more. This shows that negotiations are of great importance especially in the creation process of such co-operation approaches. Ideally, all the substantial differences between the communities can be discussed and solutions which are suitable to all, or at least a great majority of the actors, can be found.

Therefore, co-operation of all stakeholders of a catchment, co-ordinated action among planning sectors like land development, infrastructure and natural hazard management plus collaboration of institutions responsible for the funding of preventive flood protection or mitigation measures as well as private precaution and damage compensation are requirements for successful upstream and downstream co-operation. As already mentioned, the baseline however, is the involvement of all stakeholders and actors in the planning process. It is necessary to become familiar with each other and to build trust among the parties from the beginning on. When the actors involved know their partners, the motivation of collaborating is higher than if they are strangers. Furthermore, the proximity between stakeholders is an important factor for successful co-operation. Firstly, being familiar with each other is called social proximity. Spatial proximity, a second factor, makes meetings easier to co-ordinate and the chances that all involved parties participate are larger if they are spatially close to each other and only have to travel short distances to meetings. Having common knowledge about the technical solutions that were installed in the past or are going to be constructed in the future as well as sharing expertise is called technological proximity, the third important proximity in such co-operations. Moreover, institutions which in general regulate individual social behaviour, create a guideline for how to cope with each other. When working together with several parties it is valuable to have some guidelines for a controlled workflow.

Reasons why such co-operations are built is the expectation of maximizing the benefits for individual communities, a sharing of risks, resources and costs. Through a merging of available budgets for flood risk measures, each community in a co-operation can reduce local spending and thus, save money. Barriers for successful co-operations may be a technological lock-in, a longer duration of meetings or even a failure of negotiations.

Three forms of relationship exist with different intentions and outcomes: Competition, Egoistic and Co-operation.

As opposed to the theoretical establishment of successful upstream and downstream co-operation, in reality it is not as easy for partnership approaches to turn out in a successful manner. In many cases, stakeholders are not collaborating in an effective way and in other cases balancing all interests is not possible among them.

To sum up, the main purpose for inter-local co-operation is the shift of flood risk from urban areas to agricultural areas – from areas of high vulnerability and value to areas of lower value, in an economic sense, to keep the damages as low as possible.

# Chapter 5

# Methodology

Two different methods were used for writing this thesis; the first method is a literature review which was done to gain an overview of the state-of-the-art research of how flood risk is managed globally, and then being narrowed down to focus on Austria. The second part is the practice, which in this case is a qualitative approach, on the basis of the framework of grounded theory. The tool which was used, is a structured interview which was carried out with five experts working for the association of municipalities along the river Aist in Upper Austria, Austria. This approach seemed most reasonable in order to get the best insight into the association from different viewpoints, positions and knowledge.

## 5.1 Literature review

A literature review is an important feature in academic writing, since it broadens the horizon of the topic of interest, outlines major lines in the field of research and helps to advance knowledge (Pautasso. 2013; Seuring et al. 2008; Webster et al. 2002). Literature reviews provide essential evidence for supporting practical studies (Cowell. 2015). For this thesis it was necessary to carry out a literature review for the gathering of the theoretical background in the three chapters socio-hydrology, natural hazard problems and adaptation, and upstream and downstream co-operation. With this review of the already existing literature it was possible to gain an overview of the work in the field that already exists, and it created an opportunity to compare it to a chosen example. In this case the practical example is the inter-local co-operation along the river Aist in Upper Austria, Austria, which is presented in chapter 6. Key words for online papers and other information was entered in Google search, Google scholar or Scopus for the University of Life Sciences in Vienna search engines, both in the English and German language. If papers in German were processed, the content was translated into English and integrated into the text of this thesis. Other literature in form of books or pamphlets was borrowed from the library at the University of Life Sciences or came from the United Nations where I took part in a guided tour and gathered some information on the topic of water.

The academic software Citavi was used as a reference management system for this work.

## 5.2 Qualitative interview and other methods

Qualitative as well as quantitative research methods are widely used in different disciplines, such as sociology, history, psychology, natural sciences, etc. Experiments, standardized tests, statistical analysis and survey data were the dominant research methods until in the 1960s. This was when a shift in utilized research methods took place. Quantitative approaches were no longer satisfying for many researchers, since the downsides of this method became highly apparent. Then, the qualitative approach gained more attention (Flick. 2014; Rahman. 2016; Silverman. 2010).

Over the last few decades, the interest in qualitative research has grown considerably, as social researchers developed a new sensitivity to the empirical study of issues (Flick. 2014).

Generally speaking, what qualitative researchers want is to connect with the participants of their research and to get an insight of how they see the world (Corbin et al. 2015). The focus of qualitative research lies "on the subjective experience and perception of the research subjects" and is used to rather analyse, than to describe a topic of interest (Student Services. 2001, p. 2). The subjects studied are examined in their natural setting, due to the fact that "human behaviour is significantly influenced by the setting in which it occurs" (Atieno. 2009, p.14). The qualitative method allows the researcher to "discover the participants` inner experience" (Rahman. 2016, p.104). As a subjective approach, a small distance lies between the researcher and the data, and human behaviour can be understood, but qualitative research can also be applied to investigate why humans behave in a certain way. It can further be understood as the "analysis of words and images rather than numbers" (Silverman. 2010, p.8). In addition, a flexible nature can be attributed to a qualitative research design. Tools used in this analysis are for instance structured or non-structured interviews or participant observation (Chong et al. 2015; Shuttleworth et al. 2008; Shuttleworth. 2008a; Rahman. 2016). As Corbin et al. (2015) would say: "There are many reasons for doing qualitative research but perhaps the most important is the desire to step beyond the known and enter into the world of participants, to see the world from their perspective, and in doing so to make discoveries that will contribute to the development of empirical knowledge" (p.12).

Beyond the listed advantages, also some limitations for qualitative research exist. Due to the focus on experience and meaning in the qualitative research, Silverman (2010) argues that the contextual sensitivity could be left out. Moreover, stakeholders and policy-makers tend to not trust in results from a qualitative approach or give them low credibility. If this happens quantitative results are preferred over qualitative (Rahman. 2016). In some cases, although it became more popular since the 1960s, the qualitative approach is not seen as a ´real` methodology. The used data is called `non-quantified` data, to show that quantitative data is the standard form (Silverman. 2010). But this debate between supporters of the two methods is more a philosophical than a methodological one (Atieno. 2009). Other disadvantages of the qualitative approach are the issue that analysing the results takes a remarkable amount of time, and generalizing to the whole population though only a small sample size is used can be argued (Flick. 2014; Rahman. 2016).

On the contrary, to studying the subjective experience in qualitative research, in quantitative research objective measures are studied. When using a quantitative method, a greater distance between the data and the researcher is provided, and the analysis of the data is usually measured; with the help of mathematical or statistical means. Therefore, the researcher needs to have knowledge about statistics when using this method. Simple yes or no questions can be answered with a quantitative research design. One downside however is that in the social sciences it is likely not to be enough to generate proven or unproven results, since the human nature is more complex to be answered with a yes or no response (Creswell. 1994; Shuttleworth. 2008a; Shuttleworth et al. 2008). "Sometimes, this has led critics to claim that quantitative research ignores the differences between the natural and social world by failing to understand the ´meanings` that are brought to social life" (Silverman. 2010, p.4f). Another critique mentioned by Silverman (2010), is that qualitative researchers may see quantitative researchers as claiming everyday life methods of counting, defining or analysing to be of scientific objectivity, as defining, counting and analysing variables is a quantitative procedure. Furthermore, due to the fact that the nature of classification is inherently reductive, the analysed data cannot be understood in depth (Savela. 2018). Tools for quantitative research would for instance be formally designed experiments including control groups (Creswell. 1994). Despite the discussion whether to use a qualitative or quantitative approach, Atieno (2009) states that "both qualitative and quantitative research can be used to address almost any kind of research question" (p.14).

Case study research would be another methodology for investigating topics in social sciences. When applying a case study, theoretical models are used to be tested in real world scenarios to create more realistic responses than it would be received from a purely statistical survey. Furthermore, new technologies and areas of application can be found with the help of case studies. One downside however is, that a case study needs to be published in order to potentially lead to further research of a topic. It also could be argued that a case study focusses on such a narrow field, that extrapolation of the results does not seem to answer an entire question (Flyvbjerg. 2006; Gerring. 2017; Pikaar. 2018; Shuttleworth. 2008b). Still it has to be said that “each method is a distinctive way of approaching the world and data” (Atieno. 2009, p. 15).

For the acquisition of data from the field for this thesis a structured interview procedure was chosen using a questionnaire survey (Haregu. 2012). The reasons for the decision to select this procedure, was for this delicate topic to leave the participants in their natural environment so they feel more comfortable when answering the questions and for them to answer as honest as possible. Moreover, was it simpler and less time consuming for the experts as well as for me than when conducting interviews. The questionnaire survey which was put together comprises 22 open questions being divided into three sections: technical questions, questions regarding the inter-local co-operation of municipalities, and questions about the residents of the study area. The questionnaire can be found in the appendix of this thesis. It was my purpose to pose the same questions to each person chosen, to get an idea of different insights or approaches towards the association. While gathering information on theoretical background, some specific questions about the local co-operation along the Aist came up. So, during the process of collecting theory the questionnaire was created. It was an iterative process.

### 5.2.1 Selection of the study area

The study area along the river Aist, located in Upper Austria, Austria is described in detail in chapter 6. It was chosen as a topic of this thesis because, being established in 2007, the inter-local co-operation is a relatively new project in a federal state in Austria which is subject to flooding on a regular basis (Habersack et al. 2012; Puchinger. n.d.; Thaler. 2014). Since I spent my childhood in Upper Austria, had a summer job collecting data about the river Aist and was working with one of the interviewees for one of my Bachelor theses´, I chose to investigate on this co-operation project along a river in Upper Austria. Furthermore, at the beginning of the thesis´ writing process, I had the idea of interviewing farmers in the area about their opinion and view towards the association along the Aist. It is known from experience, that some people living in rural areas are more open to people who speak “their” language. I was aware that some farmers have a strong dialect and being familiar with the native language could be an advantage for me and the gathering of data for my thesis.

In the end, including farmers in the questionnaire could be a whole topic on its own, so I did not question them for this work.

### 5.2.2 Subjects studied

Before the written questionnaires were sent out to 8 experts, each of them was contacted via telephone. Either the interviewees were reached personally or their secretaries, which were happy to forward my concern and were exceptionally helpful. From the association along the river Aist several members with different positions, including public administration, a consultant, as well as engineers from outside the union, like civil- or counselling engineers, plus one person working for the Service for Torrent and Avalanche Control, were selected. This mix of public and private authorities was chosen to answer the questionnaire survey because having a variation between the interviewees regarding their position, knowledge, education and viewpoint seemed most reasonable to me. The goal was to get further insight into the topic.

The interviews and phone calls were carried out using the German language. To be used in the thesis the gathered data was then translated into English.

### 5.2.3 Time and duration of research

The questionnaire was sent out in July 2018 leaving the interviewees two weeks for replying and returning the answered document. In the first round (in the beginning of August) I received only two answered questionnaires. Two of the chosen experts immediately referred to the chairman of the association to answer my questions, as giving out information was up to him. Since I did not receive information in the planned scope, I had to contact the other stakeholders to ask them again to take part in the survey. In the second round of collecting the questionnaires I received another two replies and got the answer from another member of the association to contact the chairman, as being the man in charge for such questions. The last survey was returned in the end of August 2018. To sum it up, it took 4,5 weeks for me to send out the questionnaires and receiving all the information I needed.

### 5.2.4 Data analysis

An approach on the basis of grounded theory was chosen for the analysis of the data. "Grounded theory is a method of qualitative-interpretive social research" (Aspalter. 2012, p. 11). Glaser et al. (2013) state, that grounded theory could be used in a broader field, than only qualitative research, and in different ways than it is currently done. This restraint is apparent because graduate programmes worldwide teach this method in a creativity-limiting way where it´s resources and potentials cannot be fully explored. Although this methodology was developed by two sociologists, apart from social sciences, it is widely used in other fields as well (Corbin et al. 2015). The basic idea of the grounded theory, invented by Glaser and Strauss in the 1960s, is to "construct theory which is grounded in data" (p. 4) and is different to other methods because "it serves the phenomenon being studied" (Birks et al. 2011, p.16). Moreover, data collection, data analysis and the construction of the theory are created during the research process, which was the case for this thesis. "This iterative cyclical process is called theoretical sampling, the generation of theory while collecting data and analysing data" (Aspalter. 2012, p.12). What will be essential for the research does not have to be defined from the beginning on but will become apparent during the process of researching. Observations and interviews are the most frequent ways of collecting data, however with this theory data can be collected by a variety of means and any type of written, recorded or observed material is acceptable to be used (Aspalter. 2012; Chong et al. 2015; Sbaraini et al. 2011; Suddaby. 2006). One technique applied in this method is coding. It is a process of analysing the gathered information by comparing and contrasting it, also called the "constant comparison method" (Denzin et al. 2000, p. 783). Besides coding, according to Birks et al. (2011) there are several more methods, for instance theoretical sampling or writing memos, which researchers find logical and therefore attractive. As Suddaby (2006) remarks, grounded theory is not a method which is easy to use, and it is definitely no excuse for the absence of methodology.

The responses from the interviewees in the questionnaire survey were collected and confronted. Since the survey for the experts was standardized, the data was already grouped and therefore it made it easier to look for differences and similarities. For a better differentiation of the answers, each interviewee was given a certain colour.

### 5.2.5 Anonymity

Due to the new regulation of the European Union on the processing of personal data (General Data Protection Regulation) it is not allowed to name the interviewees by name or exact position (Council of the European Union. 2016).

# Chapter 6

# Association of Municipalities against Flood Risk

# “Hochwasserschutzverband” at the River Aist in Austria

## 6.1 Mitigation of flood risk in Austria and legal tools

The focus is being laid on Austria now, since the association along the Aist in the practical part is in Austria and in order to create a feeling for how flood risk is handled in this country. In their 2009 paper, Holub et al. give a legal overview of legislation, risk transfer and awareness building in Austria related to hazard reduction and mitigation. They found that strategies to prevent losses from natural hazards have already existed in Austria for more than 500 years. Around 1850 the main idea of reducing effects from natural events was to build protection structures in the upper parts of catchments. In this way an avalanche, for example, was held back at its start, so it would not even get the chance to become big and dangerous for houses or villages further downhill (Holub et al. 2008). Up to the 1970s the approach to mitigating these events was deflecting them into areas which were not populated, especially in the case of floods and avalanches. Back then, Austria was not as highly populated as it is nowadays - this is supported by demographic information provided by Index Mundi (2018). According to this data portal, where unfortunately numbers are only dating back to the 1960s, the population density in the year 1961 was 85 people per square kilometre increasing to a value of 106 in 2016 (Index Mundi. 2018).

In Austria, the Federal Ministry for Sustainability and Tourism, formerly known as the Federal Ministry of Agriculture, Forestry, Environment and Water Management is responsible for “water issues” (Federal Ministry of Sustainability and Tourism. 2018). Apart from flood protection of the Rivers Danube, March and Thaya which is handled by the Federal Ministry of Transport, Innovation and Technology, the responsibilities of river catchments in Austria are divided into two parts. The Austrian Service for Torrent and Avalanche Control (WLV = Wildbach-und Lawinenverbauung) handles flood protection of torrents and its catchment areas whereas the Federal Water Engineering Administration (FWEA) is responsible for flood protection on all other waters, for example federal rivers and transboundary waters (Habersack. 2015).

As stated in the Austrian Forest Act (1975) § 11, every catchment must be classified according to hazard zones (Rechtsinformationssystem des Bundes. 2016). The development of hazard zone maps was triggered by severe flood events in the years of 1965/66 in the south of Austria (Carinthia and East Tyrol). These events showed how destructive natural events can be to the environment and the economy (Lebensministerium. 2009; Lebensministerium. 2011). The first hazard maps were maps of the areas prone to torrential floods and avalanches, developed following the passage of the Austrian Forest Act (1975). Subsequently hazard maps indicating flood risk in the lower parts of the catchments, where the Federal Water Engineering Administration is in charge, have been developed since the 1980s. These maps categorize the catchments into areas of different colours, where each colour represents certain characteristics. As can be viewed in table 4, the red hazard zone marks areas were the permanent utilization for settlements and traffic purposes is not permitted or only with extraordinary efforts for mitigation measures. The second colour used is yellow which marks the zones were permanent settlements and traffic is impaired by hazardous processes. The areas which are not that endangered but require future mitigation measures are coloured in blue. Brown shows areas affected by landslides and rock fall, but not by floods or avalanches. As a last colour purple is used in hazard zone mapping to indicate sectors which can be used as protection, e.g. natural retention basins or protection forests (Bundesministerium für Land-und Forstwirtschaft, Umwelt und Wasserwirtschaft. n.d.; Fuchs. 2014; Holub et al. 2009).

| | |
|---|---|
| Red Zone | Areas where the permanent utilization for settlement and traffic purposes is not permitted or only possible with extraordinary efforts for mitigation measures |
| Yellow Zone | Areas where a permanent utilization for settlement and traffic purposes is impaired by hazard processes |
| Blue Zone | Areas to be provided for future mitigation measures |
| Brown Zone | Areas affected by landslides and rock fall (not floods or avalanches) |
| Purple Zone | Areas which can be used as protection, e.g. protection forests or natural retention basins |

Table 4: Hazard Zones in Austria (based on Holub et al. 2009).

In most cases, these kinds of maps are prepared for the area of an individual community and “are based on a design event with a return period of 1 in 150 years, and an event occurring more frequent with a return period of 1 in 10 years” (Holub et al. 2009, p. 525).

Hazard maps display the opinions of experts on the reoccurrence intervals of natural events but do not have the status of normative acts according to the law. However, if plans of an administrative body are in conflict with the characteristics of a hazard zone, the outcome of the conflict must be justified technically. Hazard zone maps are regarded as “prognostic expertise” in Austria (Fuchs. 2014). They are measures that do not become legally binding in land-use planning activities (Holub et al. 2008; Holub et al. 2009). Nonetheless hazard maps are internally binding for the Austrian Torrent and Avalanche Control Service (Fuchs. 2014). In order to create safe surroundings for people, a shift from structural protection measures to integrated flood risk management and even socio-hydrology, as is explained in detail in chapter 2, is happening (Hartmann. 2011). Spatial planning and building regulations, are non-structural measures that are effective tools allowing to take preventive action (Di Baldassarre et al. 2013). Building regulations and structural measures are applied to avoid an increasing risk potential. Another measure stated by Holub et al. (2009) is limited re-zoning at a local governmental level. Every federal state in Austria is responsible for its own guidelines. The regional development plan is the concept were future land-use activities, settlements and open space as well as infrastructure for communities are determined (Land Steiermark - Amt der Steiermärkischen Landesregierung. 2018). Every community has its own plan which must follow the land-use and building plan of the municipality. These land-use and building plans must coincide with the regional policy of the federal states which have to go in line with the overall Austrian regional concept. Hazard zones must at least be mentioned in regional development plans, but the level of detail shown in the plan varies between the federal states.

On paper it appears as if it would be quite easy to figure out where building limitations are to be followed. However, conflicts arise in areas where land developing activities are authorized but then later a building ban is put in place due to a high risk of hazard of some kind, in exactly this already authorized space. It is important that these conflicts are addressed in natural hazard management and solutions found which are admissible for all stakeholders involved. “With respect to natural hazard management, legal regulations related to land-use decisions are accompanied by the principle of governmental loss compensation in Austria” (Holub et al. 2009, p. 527).

“HORA” – Natural Hazard Overview & Risk Assessment Austria, is a risk zoning tool for most parts of Austria were civilians can look up on a map which parts are at risk for certain natural hazards (Bundesministerium für Nachhaltigkeit und Tourismus. 2015). “With respect to the idea of integral risk management, the interaction between prevention and precaution has to be highlighted, and respective incentives for loss-reducing actions on local level should be provided in order to reduce the vulnerability to natural hazards in Austria" (Holub et al. 2009, p. 535).

Fuchs (2009) argues that inequalities in society, low levels of education or gender do not set the conditions for vulnerability to natural hazards. Institutional parameters created from land use regulations, risk transfer mechanisms, desires of individuals and expected economic benefit from a governmental point of view "can be used to reduce social vulnerability to natural hazards" (p. 347).

Insurance against natural hazards is not compulsory in Austria (Fuchs et al. 2017) or Germany (Kreibich et al. 2005). However, this varies for the different countries in Europe – in Switzerland for instance, in most parts, insurance against natural hazards is mandatory (Siegrist et al. 2006). Damages which are covered by ordinary insurance companies in Austria would be hail, rock fall, pressure due to snow load, sliding processes and storm damage, but not floods. This is the reason why an additional insurance in flood prone areas is useful to avoid high costs for the individual in case of damage. In addition, governmental aid plays an important role in compensating losses from e.g. floods or avalanches (Holub et al. 2009) which will be discussed in more detail in sections 6.8.2 and 6.8.3.

## 6.2 Characterizing the catchment area of the river Aist

The river Aist is located in Upper Austria a region in the central-north of Austria, Europe. The river is a tributary of the river Danube, has a total length of about 72 km and a catchment area of approximately 650 km². The two branches of the rivers Feldaist at the left and Waldaist at the right, as shown in figure 7, join to become the river Aist before entering the river Danube.

Figure 7: Map of Austria showing Upper Austria with a focus on the catchment area (circled part) of the river Aist (adapted from Flussperlmuschel. n.d.).

The landscape of the watershed area of the Aist is granite hill country being described by gentle valleys and flat, broad hilltops. This region in the north of Upper Austria called the "Mühlviertel" is part of the Bohemian Massif (a part of the geology of Central Europe) which stretches from the north of Austria to the Czech Republic, eastern Germany and southern Poland (Fuchs et al. 1980).

The river Aist has a course from North to South entering the river Danube (at kilometer 2106,2) shortly after the Austrian city of Linz, the capital city of the federal state of Upper Austria. On its way to the Danube, the Aist passes wide and narrow valleys as well as gorges until it reaches the geological plain of the Danube river.

With a number of approximately 56.000 people living in the catchment area, the population density varies along the course of the river; upstream it is sparsely populated, further downstream the population becomes more concentrated and at the city of Schwertberg, which is the last larger city before the Aist enters the Danube, the population is so dense, that at some stretches buildings enclose the river from both sides leaving no space for water retention.

Being a mainly rural catchment, especially upstream, large proportions of the land are used for agriculture and forestry. However, it is a quite diverse catchment; naturally protected wildlife- and recreational areas (a “Natura-2000“-site) but also sections of densely populated areas can be found (Seher et al. 2016).

The Aist originates at an altitude of about 1000 meters above sea level (m.a.s.l.) and enters the Danube at approximately 240 m.a.s.l. The median annual temperature in the upper region of the river Aist is 5,5 degrees Celsius whereas downstream at the Aist outlet the temperature is about 3 to 4 degrees higher; reaching up to 9 degrees Celsius. Rainfall in the watershed area is about 800 mm per year, which is the lowest rainfall intensity in the federal state of Upper Austria. Further West, within the Alps, three times the amount (about 3000 mm per year) of rainfall can be expected (Amt der Oö. Landesregierung. 2009; Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft. 2015; Land Oberösterreich. n.d.).

## 6.3 What happened along the river Aist?

In the beginning of August 2002, Central Europe was scene for catastrophic flood events with high personal and economic losses (Grothmann et al. 2006). Two consecutive rainfall events with disastrous outcomes happened in the federal state of Upper Austria, Austria. Until then the maximum discharge for people to still be save, was a peak flow of 280 $m^3/s$. The discharge measured after the first rainfall event was 327 $m^3/s$ and 339 $m^3/s$ after the second. For the two public authorities, the Federal Water Engineering Administration and the Service on Torrent and Avalanche Control, and the affected downstream municipalities, it was inevitable to find solutions for anticipating a similar catastrophic magnitude and tremendous damages in possible future flood events, which was the beginning of a mutual project of the affected municipalities for mitigating flood damages (Habersack et al. 2012; Puchinger. n.d.; Thaler. 2014).

## 6.4 Hard facts about the association of municipalities along the river Aist

After the heavy rainfall events followed by catastrophic flooding in 2002 the national, regional and local authorities knew that something must be done in order to prevent comparable incidents from happening in the future. A regional study in connection with further possible flood risk management options was commissioned by the Federal Ministry of Sustainability and Tourism. In 2005 after several discussions with stakeholders, mayors of the affected municipalities, other important public authorities, experts and engineers, it was obvious that an effective management of flood risk in a catchment area of this size is only possible if all the municipalities collaborate. Therefore, in 2007 the association of municipalities along the river Aist, including public authorities, administration and civil engineers as well as the Service for Torrent and Avalanche Control, was officially established (Hochwasserschutzverband Aist. n.d.). Extensive political support was received by the co-operation, due to the fact that to the state government of Upper Austria this union is seen "as a model for catchment-oriented flood risk management" (Seher et al. 2016, p. 61). In this case, public utility companies, for example the Regional Road Authorities or the Austrian Federal Railways are co-operating with local, regional as well as national authorities (Seher et al. 2016). In comparison to other existing inter-local co-operations in Austria, like the one in the Triesting-Tal in Lower Austria, the structure of the association along the river Aist is therefore more complex (Thaler. 2014).

### 6.4.1 Scope and goals

"The Aist co-operation is disaster driven" (Seher et al. 2016, p.59). Counting 27 member-municipalities in the watershed area of the rivers Feld- and Waldaist which further downstream conjoin to become the river Aist, the first two goals of this union were the extension of the association to all affected municipalities along the river Aist and, creating awareness in the affected municipalities for the prevention of causes of flood risk (including land use plans or reducing the sealing of the surface which prohibits the infiltration of water into the ground). The superordinate target however, lies in the reduction of the water peak and in a translation and deceleration of the flood wave in order to protect permanent areas of settlements in the catchment area from future flood events with a magnitude of a 100-year reoccurrence (Habersack et al. 2012; Initiative für ökologischen und nachhaltigen Hochwasserschutz - Aist. 2012).

Reaching these goals will happen through applying the catchment-based approach (CBA). This approach is described in more detail in chapter 4.3.2. Reserving unsettled areas for natural retention purposes and therefore creating more space for water is one step. Secondly, large measures in densely populated sections and a series of small measures upstream in the sparsely populated areas will be taken to tackle the problem - retention of a volume of 350 000 m² and 650 000 m² needs to be created (Initiative für ökologischen und nachhaltigen Hochwasserschutz - Aist. 2012). Because this project is carried out by several authorities, a basis of measures, which are compatible with the requirements of the European Water Framework Directive, is created (Hochwasserschutzverband Aist. n.d.). The European Water Framework Directive is a framework for community action in the field of water policy.

### 6.4.2 Progress – goals reached?

Until 2015 several measures of different kinds were realized; retention basins of different sizes were constructed, and other small measures were implemented (for details see the website of the association). The last one according to the website of the Federal State of Upper Austria was initiated in 2015 and finished and implemented in September 2017 (Amt der Oö Landesregierung. n.d.). However, on the official website of the association of municipalities of the river Aist there are only two of the large projects listed which were realized and two others which are on hold. Since there is no date mentioned it is not clear since when these projects are on hold, and if they still are. The other possibility is that the website was not updated and that the projects were already realized. The Federal Ministry of Agriculture, Forestry, Environment and Water states that in every project there are multiple factors determining the implementation of measures. Therefore, there is always a risk of not reaching the planned goals (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft. 2015).

### 6.4.3 How are landowners informed about recent projects?

According to the official website of the association landowners are informed about planned or ongoing projects through an open dialog with the public authorities. They are integrated in decision-making, planning and the approval status of projects by the association. The Ministry of Agriculture and the Federal State of Upper Austria have developed a frame contract of how to compensate landowners in case their land is needed for flood protection or mitigation measures (Hochwasserschutzverband Aist. n.d.).

### 6.4.4 Financing

According to the official website of the association of municipalities along the Aist the financing of projects is made possible due to the following funding authorities:

- Funds from the European Union,
- Funds from the state of Austria (“Wasserbautenförderungsgesetz“),
- Funds from the Federal State of Upper Austria.

The association of municipalities along the Aist is financing 15% of the costs for their projects (Hochwasserschutzverband Aist. n.d.a; Seher et al. 2016).

## 6.5 Radio interview with the chairman of the association (June 2013)

The chairman of the inter-local association of municipalities along the Aist was giving an interview on a regional radio station in June 2013. The person leading the interview is not only working for the radio station but was part in the civil initiative pleading against the construction of large retention basins (which were part of the flood management strategy).

After the large flood events in 2002 it was not expected to have a similar event in such a small period of time happening again. When it was looked at the damages from the recent flood event, according to the interviewee, nature´s impact on humans cannot be controlled because it is a power of its own, which strikes whenever it wants to and to a random extent. In the case of this flood event the municipalities along the Aist were lucky – the measures taken to keep access water under control fulfilled their purpose and operated the way they were expected to.

On June 6$^{th}$, 2013, the chairman stated the following (translated by the author of this thesis): "The catchment of the association of municipalities is structurally divided into three parts: south, central and north. Municipalities, relief units and other stakeholders as well as interested or affected citizens had the possibility at three planned discussion events or information sessions to discuss, to receive further information and gain additional knowledge about future projects in the catchment. Due to the recent flooding in 2013 though, these information sessions were postponed since people affected have more important topics to deal with at the moment, than taking part in a discussion. Furthermore, the fire fighters are operating on site wherever they are needed now. Another reason for finding alternative dates for an information event is, that we wanted to include recent findings and possible improvements recently experienced in the discussions. People should also be able to gather more information on the recent event.

The goal is to have committees in every municipality which are continuously working on flood risk management strategies and create sustainable solutions. Building awareness should be executed in collaboration – all involved groups of people (public authorities, emergency forces, the existing civil initiative, engineers, civilians, etc.) are invited to contribute. People living in affected areas tend to have knowledge and experience in such events from the past and can be a valuable contribution for everyone else in the future. This is not to underestimate and therefore private individuals are encouraged to take part in such meetings at the same level as it is important for engineers and hydrologists to contribute.

The regional study carried out by a scientist from the University of Life Sciences in Vienna is the bases for the definition of areas which are to be protected from floods. When being familiar with what areas to protect the next step is to evaluate suitable strategies. It has to be said however, that there is no flood protection that is 100% safe. Subsidies are only granted for $HQ_{100}$- events which in our case therefore became the level of protection.

Several measures are to be considered: natural retention areas, small or large retention basins. Large retention basins are to be preferred over small retention basins, but in case there is only space for a small one, the small one is to be constructed. The second important issue is bed load. Erosion and bed load transport management are two important topics to deal with in flood events and have to be handled with care. This is due to the fact that not only water is transported by floods but also a lot of material which is deposited at different locations, which has the potential of creating a lot of damage to people and nature. So, the idea is that in January 2014 the goals are to be officially presented and initiated. How fast planned projects are implemented is depending on the monetary situation and funds being granted but to the association it is important to have clear goals to focus on. The working title: ´eine Region baut sich ihren Hochwasserschutz` – "a region is creating their own flood protection" implies that protection against flood events is established together as a region involving all stakeholders.

So far, small measures have been taken with a scope of €30 – €200.000 (all together a sum of €2,8 million was spent) which already are in use supporting regional and local flood protection. Until summer 2015 another € 2,8 million are going to be invested in further measures.

If the public is well informed and the acceptance of the stakeholders is high, making a progress in such a project is easier since less discussions have to be held with landowners or farmers due to the fact that people are already informed and know about the issue and its consequences. As the 40 organized events for citizens show, landowner involvement was practiced from the beginning on. To inform affected people and communicate ideas and plans and invite them to be part in the working and developing process is important to us. All questions actors posed to the association of municipalities were collected and are going to be answered. This is an activity to show the public that they are welcome to participate and how important involvement of the public is to the association of municipalities.

The planning of projects was paused because it was more important to involve the public and define goals of protection than to continue with building structures that could not be satisfying.

Opposed to some people questioning the progress and sense of purpose of the association, the evaluation carried out by the expert from the University of Life Sciences in Vienna was only possible because all the measures and steps taken so far, for the mitigation and protection from flooding, are to be regarded as necessary. They until now fulfilled the goal of flood protection and will be used for further projects and strategies carried out in the future.

A paradigm shift took place; from the local survey carried out in the beginning it was evident that 8 mio. m³ of water which were involved in the flood events in 2002, had to be dealt with and found ways to protect the public from these amounts. After discussions in 2005 and 2007, the demands of the civil initiative plus discussions with civilians lead to the paradigm shift from managing a certain amount of water to re-defining the goals of protection. These protection goals were found as follows: a 2D- hydrological model is going to show the runoff from north to south in the catchment. Due to the model, the threatened sectors are identified, and it is primarily settlement areas which are to be protected. How the evaluation of these identified areas is going to be done is not clear yet, but settlement areas definitely have a higher priority than agricultural areas. After identifying areas that need protection and to what extent, suitable measures can be found in a process of discussion which is probably not the easiest to go through, but it will definitely be exciting. This involvement of stakeholders in finding ways of protection is of great importance to the association, as participation and working on this common project is a major way of experiencing how this process is developing over time. And with gaining more experience involving more people is possible. Acceptance is higher when actors are heard and when their opinions are integrated and involved in the progress, in contrary to decisions which are being only made by authorities and engineers and are subsequently presented to the public. Moreover, trust is very important in the realization of projects that involve the public. This shift in strategy showed the courage of the authorities to change their minds towards more reasonable goals and to also learn from passed events. In the first place the idea of the association was different.

This inter-local association also wants to show the European Union that the involvement of affected people at different levels is necessary in order to create a sustainable and meaningful protection against flooding and that more money should be made available for such protection strategies” (Josef Lindner. June 6th, 2013).

## 6.6 Civil initiative

Civil initiatives in flood risk issues express their demands for a better flood protection than offered by public authorities. According to Hartmann (2011) “typically, such initiatives are launched after a flood, when the egalitarian rationality dominates floodplains and landowners perceive floodplains as dangerous terrain” (p. 104). Generally speaking, members of such organizations tend to be well informed about their issue and have a tendency of being open to new ways of managing flood risk (Hartmann. 2011).

A civil initiative at the Aist was established in 2011 to campaign for ecological and sustainable flood protection. Members of this initiative are affected neighbours who are experienced in flood issues and who want to protect the environment by achieving a better, integrative flood protection system (Flussdialog. 2012; Hartmann. 2011).

The organization is disapproving of the implementation approach the association of municipalities chose concerning measures of flood protection. They demand a decentralized flood protection scheme. The task of decentralized flood protection is mainly to prevent surface runoff through deep drainage or surface retention (Hartmann et al. 2018). Furthermore, they believe that the ecology and nature is not respected and taken into account in planned projects and they are afraid of consecutive damages on the environment. Therefore, in 2012, an online poll was created for the public to speak out and for authorities to hear them.

92% of the respondents (it is not mentioned though how many participants took part) want more space for the river, so it can get back a bit of its natural structure. A semi-natural river bed is part of their demands, including meanders creating the opportunity for the river to expand further. According to the initiative, the association of municipalities has planned to construct a few large retention basins. The initiative concludes that neighbours prefer natural retention options without having to use concrete, like ponds or small lakes. However, when it comes to a decision in size, the respondents are in favour of a higher number of small basins in contrast to having a few large ones. They argue that small basins are not as expensive as larger ones, reduce erosion in the catchment and can be easier integrated in the natural scenery. Furthermore, some farmers are afraid, that due to the construction of structural measures an accumulation of sludge and bed load in the river could occur and that this could have subsequent problems created for agriculture. As a last point, 86% of the respondents would like to have broader riparian zones and the rededication of adjacent areas from agricultural space into riparian forest (Flussdialog Oberösterreich. 2012).

## 6.7 Findings from the interviewees

Significant for the establishment of the inter-local co-operation between the municipalities along the river Aist in Upper Austria, was the effort of a former mayor of an affected community in the catchment who created the association based on a regional study which was carried out in 2002.

Although the association of municipalities was established in 2007 (eleven years ago), there are still some structural measures which were not yet implemented, are still being discussed or are recently being built. The goal, to protect the catchment area from a 100-year reoccurring flood event is not yet fully reached. But the process is ongoing. Currently the association is in preparation for the construction of two retention basins north of Freistadt (one of the affected cities in the area). Current negotiations with the landowners are going to decide on the subsequent actions taken by the association concerning these basins. In addition to that, there are still some smaller measures to be realized.

Land which seems ideal to be used as space for retaining water in the catchment, was designated through certain criteria in the regional study carried out in 2002. The department for the water district of Linz (the capital city of Upper Austria), the Technical Service for Torrent and Avalanche Control for the Mühlviertel (the region where the Aist catchment is located) and a civil engineering office have been working together and suggested the selected locations. During the course of finding suitable land for retention purposes, additionally, a hydraulic two-dimensional (2D) analysis was carried out to determine the run-off characteristics of the catchment.

Most of the land is owned privately and still needs to be provided for water retentions in case of floods. In the process of finding suitable areas for water retention, when the landowners are approached, in many cases the affected persons´ first reaction is denegation. This is mostly the case for people who need their land as an economic basis for their lives. Others, whose lives are not depending on the productivity of their land, see things a bit more relaxed. In exchange for providing land temporarily for flood protection purposes to the public, landowners are either compensated in a monetary form, or land is exchanged. In order to have a standardized framework, guidelines for land compensation were developed. If a monetary compensation is preferred, there are three options: a one-time payment, occasional payment or purchase.

But not only people working in the agricultural sector are involved in this flood issue – everyone living in the catchment area is affected. Still there is a focus on protecting the infrastructure, residential and commercial areas. Only forests and agricultural areas are not protected by flood risk measures, but as discussed before farmers are most involved in providing their land as space for retention measures.

Problems in the execution of projects are constantly arising. Possible obstacles are for instance discussions with the civil initiative about retention basins, the availability of land or the resistance of landowners who do not want to provide their property for flood protection purposes (especially for the construction of retention basins). A conflict of interests between upstream and downstream landowners is another issue; the ones upstream do not profit from measures being implemented on their grounds, so they do not see a reason for trading their land. The downstream landowners are the one´s affected by flooding and are mostly in favour of measures to be taken against floods, as these are taken upstream. Since, as private persons, they are probably not heard, they are represented by the association of municipalities to support their concerns.

At the official website of the association there are two projects, two retention basins around two towns, which were said to be carried out in 2011, but are still not realized – they are officially on hold. One reason for putting them on hold and why the construction has not started yet, is the discussion about the economic efficiency of those basins. People around the area where the basins were planned, disapprove of these projects the way they were suggested by the commissioned engineers. Moreover, they believe that the planned structures would disturb the natural scenery. Apart from that, issues with the financing of the basins came up and according to the law of funding projects in hydraulic engineering they would not be cost-effective anyway. As a consequence, the construction of these two basins was not realized.

The co-operation along the Aist is not only implementing structural measures, also non-structural measures (for a detailed description of structural and non-structural measures see chapter 2.3.) receive more and more attention. Just to name a few non-structural measures that have been carried out: for instance, flood risk plans that have been developed, on the basis of the existing hazard zone maps of the region, deconstruction measures have been realized, and people have also been moved away because of the hazard. To the experts, these kinds of measures have the same importance in flood risk management as structural measures do.

Generally, projects along the Aist are funded through the disaster fund (described in section 6.8.2), through funds from the European Union and through the Ministry of Sustainability and Tourism.

Since the establishment of the co-operation of municipalities there has been a change in strategy. Originally, the goal of the association was to realize a protection scheme against flood events with a magnitude of the ones happening in 2002. With its size, they would have a reoccurrence factor of 300 to 500 years. Due to the fact that funds in Austria are only available for protection from flood events with a 100- year reoccurrence and because there was not enough land available for protection measures of that extent to be carried out, the protection goal was reduced to a 100-year reoccurrence factor. This was done in guidance with two advising engineers from the federal government of Upper Austria and the University of Life Sciences in Vienna. The civil initiative also demanded a change in the planned strategy, because it did not approve the idea of 24 retention basins being constructed. Therefore, alternative measures will be taken to compensate the planned basins and it still has to be investigated if certain towns are already protected from a 100-year reoccurring event or if they still need some protection.

Although there are difficulties in the execution of plans, because of factors outside the association which are interfering with the progress of protecting the catchment area, co-operation within the municipalities is working really well. All stakeholders involved are pulling in the same direction and want to fulfil the newly established goal: to protect the people in the catchment from flood events of a magnitude of a 100-year reoccurring event.

Not only has a change taken place in the strategy of the protection goals, there has also been a shift in the approach of how hydrological projects are managed generally. The classic flood defence strategy has been replaced by an integrative flood risk management approach. Today, societies are more involved and integrated in projects of hydraulic engineering than two centuries ago. However, the association of municipalities along the Aist, from the beginning on, has always integrated the public and open communication was one major aspect in their strategy. What has changed, also for the co-operation along the Aist, is the sensitivity of stakeholders towards small retention projects. Compared to water management before the year 2000, there has also been a shift in the way how water and people are perceived. Transboundary, interdisciplinary planning, the integration of the water ecology and a more holistic approach in flood defence has become more important since then. Participation of the public by law, was introduced in 2007 through the European Floods Directive. If protection measures are planned (for the protection of humans), the impact of the measure on the environment is always taken into account. In case of the inter-local co-operation along the Aist, the evolvement of the rivers and the groundwater are very important factors to consider.

## 6.8 Some legal tools for the protection from flood risks in Austria

### 6.8.1 The water rights act

Flooding, which occurred in the year 2002 had such a large impact, that authorities on an international basis had to react. This, in 2007, led to the establishment of the European Floods Directive. The Water Rights Act §38 is the legal tool through which the EU-Floods Directive was transferred into Austrian law. According to this directive there are three phases in the implementation of reducing flood risk (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft. 2015; Bundesministerium für Nachhaltigkeit und Tourismus. 2018):

1. *Defining areas of risk.*
   The process of assignation was completed in 2011. All over Austria 391 areas were defined as potentially prone to flooding.

2. *Creating hazard zone maps.*
   Until 2013 all 391 areas of risk were put in a map with three different probabilities of flooding.

3. *Establishing flood risk management plans.*
   With the gathered information and data from the first two steps, it was possible to design management plans for the designated areas.

### 6.8.2 The Disaster Fund

In January 1951, large parts of the East and South of Austria were deeply afflicted by the most catastrophic avalanche disaster happening since 1689 (Bundesministerium für Nachhaltigkeit und Tourismus. 2012). This event was the trigger for establishing a law for providing people harmed by avalanches with financial support and governmental aid. After severe flood events in 1965/66 (which also were the decisive factor of the establishment of hazard zone maps, as mentioned in section 6.1), it was deemed necessary to make this financial support permanent and – the so-called "disaster fund" was created (Bundesministerium für Finanzen. 2012). The disaster fund provides "the legal basis for the provision of natural resources for preventive actions to construct and maintain torrent and avalanche control measures, and financial support for the Länder to enable them to compensate individuals and private enterprises for losses due to natural hazards in Austria" (Holub et al. 2009, p. 528).

This disaster fund still exists in its original form. It is financed by corporate taxes, income taxes and taxes on capital yield which can be calculated as annual costs for a private household of about € 7, - and about € 30, - for a business enterprise. Holub et al. (2009) and Fuchs (2009) state, that money which is not spent in the corresponding year goes to a reserve where the maximum amount accumulated is € 29 million. A disaster with losses above average places a liquidity strain on the fund. Still, the distribution of resources is legally defined – a certain percentage needs to be spent on passive flood mitigation measures as well as on the prevention of damage from avalanches and floods. To gain financial support for losses originating from natural hazards, the compensated parties do not have to give anything in return – "people do need neither to pay written premiums nor do they have to contribute to the available funds otherwise" (Fuchs. 2009, p. 342). Additionally, it needs to be said that funding will only happen up to a certain percentage of the overall losses to both legal entities or individuals, so it is not total amount of damage which is compensated (Fuchs. 2009).

Furthermore, amongst other measures taken, with money from the fund the Austrian Service for Torrent and Avalanche Control is able to carry out research for future measures. Subsidies are assigned to damages on infrastructure and for damages on motorways and waterways. 50% of the expenses for the overall losses are met by the disaster fund as well. The loss payment lies in the responsibility of the federal states. First, a locally-based commission of experts records the damages. As a second step the compensation is paid-out by the province to the affected parties. However, there is no law which makes loss compensation a legal right and every federal state has different conditions for the damage- or loss compensation (Holub et al. 2009).

### 6.8.3 The Solidarity Fund

Another form of financial aid after natural disasters is the “Solidarity Fund” of the European Union. It was created after severe flood events hit several countries in Europe in 2002 (Hartmann. 2011). It is a response to aid disaster-struck regions in Europe and has already been used 80 times after catastrophic events like floods, forest fires, storm, earthquakes and drought. Already 24 European countries have been supported with a total amount of € 5 billion, as is displayed at the website of the European Commission (n.d).

Table 5 shows events that happened in Austria where people concerned were compensated for at least a small amount. After the extreme floods of August 2002, the total overall damage was about € 2900 million. The amount of granted aid was € 134 million which accounts to about 5% of the total damages. Regional floods in August 2005 in Tyrol and Vorarlberg (other federal states in Austria) produced a damage of € 592 million where the European Union Solidarity Fund paid € 14,8 million. In addition, € 240 000 and € 21,7 million were given to neighbouring countries after flood events in November 2012 and May 2013, where the damages were as high as € 10 and € 866 million respectively. To sum up, for these natural hazards in Austria from August 2002 until May 2013, the total of granted aid from the European Union was € 170,74 million. In comparison with the other European countries which received monetary aid from the European Union Solidarity Fund, Austria lies on 5$^{th}$ place. 19 out of 24 countries had less serious emergency situations requiring less money for post-disaster aid than Austria (European Commission. 2018).

| Beneficiary State | Occurrence | Nature of disaster | Category | Damage (million €) | Aid granted (million €)*) | Total aid granted (million €) |
|---|---|---|---|---|---|---|
| AUSTRIA | August 2002 | Floods | **major** | 2 900 | **134** | **170.74** |
| | August 2005 | Floods (Tyrol, Vorarlberg) | regional | 592 | **14.8** | |
| | November 2012 | Floods (Lavamünd) | neighbouring country | 10 | **0.240** | |
| | May 2013 | Floods | neighbouring country | 866 | **21.7** | |

Table 5: European Union Solidarity Fund Interventions for Austria since 2002 (from European Commission. 2018).

# Chapter 7

# Discussion

Socio-hydrology, management and adaptation strategies as well as ways of coping with the hazard are important factors in flood risk management. In case of a catchment-based approach, co-operation between upstream and downstream parties is the basis for a successful management strategy. In this thesis a literature review was carried out for gathering information on the theoretical background concerning socio-hydrology, natural hazard problems and adaptation, and upstream and downstream co-operation in flood risk management. To see whether the theory is applied in practice, an example of an association of municipalities in the catchment area of the river Aist in Upper Austria was chosen, a qualitative interview carried out and the collected data compared with the literature. As the results show, the inter-local co-operation along the Aist can be used as a model for catchment-oriented flood risk management, although it needs to be considered that every catchment has its own characteristics and adjustments need to be made to suit the individual properties.

As presented in the introduction of this thesis, water-cycle dynamics are influenced with accelerating speed by the human appropriation of water resources and by the ongoing modification of landscapes in different spatial as well as time scales. Therefore, new ways of managing water resources and adaptation and mitigation strategies in flood risk management were found. This is also the case for the catchment area along the river Aist which is the central theme of this thesis.

As can be seen in this example of an inter-local co-operation, the process of organizing and establishing an association takes a lot of time, before things can get started. In case of the association along the river Aist, it took five years to establish the union. Such systems only work slowly and take a long lead time for things to be executed.

In this thesis I have found that the co-operation between municipalities in the catchment area of the Aist works well, however, the goal to protect the catchment from flood events with a 100-year reoccurrence is not fully reached yet. A change in strategy since the inter-local co-operation was established took place, which is on the one hand because of the introduction of the European Floods directive in 2007, demanding participation of the public, which was then integrated into the goals of the association. On the other hand, there was a change in the protection goal of the catchment, due to the fact that a flood defence scheme for a 300 to 500-year reoccurrence (which would have been necessary after the last devastating event) is not financed by the state of Austria and therefore, it had to be reduced to a 100-year reoccurrence protection scheme. Difficulties in reaching the goal are as follows:

- too many actors being involved; co-ordination between them is too complex and does require long lead times until projects are ready to be carried out in practice
- unforeseen problems of any kind could be arising in the process of developing ideas to their implementation
- political issues creating obstacles for implementing goals
- financial issues; not having the needed funds for the execution of planned measures or for compensating affected people
- affected neighbours; not co-operating
- civil initiatives working against public authorities.

These issues are discussed in more detail in the next sections, where the theoretical chapters of this thesis are compared to the information gathered from the questioned stakeholders of the association.

All in all, when comparing the gathered information, by means of the questionnaire survey, with existing literature about approaches and strategies in socio-hydrology, natural hazard problems and adaptation, and upstream and downstream co-operation, in the inter-local co-operation of municipalities along the river Aist, it can be said that this co-operation has been successful and fulfils the requirements mentioned by Nachtnebel et al. (2009) and Thaler (2014).

In the process of acquiring information and data about the association of municipalities in the existing literature, it was difficult to find out when projects were carried out. The official website of the union does not contain a chronology about meetings, decisions taken or implemented projects

## 7.1 Comparing Literature with received information from the experts

### 7.1.1 Socio-hydrology at the river Aist

It has been globally accepted, that an important aspect in integrated water resources management (IWRM), is “the involvement of a range of stakeholders in flood-related decision-making processes” (Begg et al. 2017, p.180). Stakeholder involvement in these processes is a crucial element in successful water resources management (Johnson. 2002; Medema et al. 2016). It is furthermore, connected with a more complex process of decision-making, since it is more difficult to reach an agreement on something the more people (and therefore a greater variety of ideas, knowledge and viewpoints is included) are part of the group (Begg et al. 2017). According to the interviewees, in the association along the Aist, stakeholders were integrated in the decision-making from the beginning on and the interaction and co-operation among them works really well. A series of information events were organized, where stakeholders were informed about planned projects and concerned people could voice their opinion. As the chairman of the association stated in the radio interview given in 2013 (see chapter 6.5), opinions were always integrated in the decision-making and planning processes, as an open communication was very important for the association. This course of action is quite innovative and very much coincides with one of the ideas of socio-hydrology, as being the new science of people and water.

Societies are being more and more involved in natural resource management issues. This is also the case along the Aist. Sustainable water use and sustainable human development are important topics for the association of municipalities, which are major characteristics of the application of socio-hydrology (Montanari et al. 2013). Residential areas and infrastructure are to be protected from future flood events with a magnitude of a 100-year reoccurrence. Furthermore, hazard zone maps were created and are available for the public, to show residents which areas in the catchment are prone to floods and are better to be avoided (Fuchs. 2014). In addition, the demands of the civil initiative to keep up the natural scenery and to be in favour of small (structural) measures contrary to building less but large structures for flood protection which might be difficult in the scenic integration, also assisted in the realization of socio-hydrological attributes.

“In recent years, strategies for the prevention and mitigation of flood disasters have shifted from a ´flood defence` approach, aimed at controlling the hazard by means of structural measures, to a ´flood management approach` based on comprehensive flood assessment studies and costs and benefit analysis” (Dottori et al. 2016, p. 632). This is exactly what happened in the association of municipalities at the Aist. A shift moving towards a strategy based on the characteristics of socio-hydrology has taken place. Early warning systems are state of the art and more detailed hazard zone maps have been (and are still being) created.

### 7.1.2 Natural hazard problems and adaptation

The catchment area of the river Aist is very vulnerable to flood events since in the downstream parts there are cities and towns along the river which are being increasingly populated, and the economic development is further encouraged. Therefore, the association of municipalities was established to create means of flood protection integrating the whole catchment. The priority is to protect the settlement areas and ideally the agricultural areas along the river upstream are used to provide space for water retention (Puchinger. n.d.). In this case, it can be clearly seen that the hazard is a mix of human action and natural events, as Wisner at al. (1994) define it. If the region would not be as populated and economically important, floods would not become a hazard.

In order to identify the flood susceptibility and vulnerability of a region or catchment area, Dottori et al. (2016) suggest a GIS-based trade-off between a physical two-dimensional (2D) hydraulic model and another index. In case of the river Aist, a hydraulic 2D-analysis was carried out for the purpose of identifying areas in the catchment which are suitable for water retention purposes in a sustainable flood protection scheme (Puchinger. n.d.).

Problems, which the civil initiative is expecting as a consequence to large-scale technical measures being built along the Aist, are higher costs for building structures, an accumulation of sludge and bedload in the river as well as more erosion happening (Flussdialog. 2012). Bed load and accumulation is a known issue along the Aist and is clearly in the focus of the inter-local co-operation (Josef Lindner. June 6th, 2013). As Pitt (2006) states, in addition to the mentioned problems above, habitat destruction can occur due to high flow rates during a flood, the accumulation of pollutants or nutrients in retention basins and contaminated sediments could pose other problems. In order to avoid these issues, the association is considering the implementation of a higher number of smaller basins, instead of few larger ones, as originally intended.

The associations´ projects are mainly financed by the disaster fund, as described in chapter 6.8.2. Other means of financing are funds from the European Union as well as funds from the Federal State of Upper Austria. A cost-allocation scheme for the co-financing of flood mitigation measures in the catchment was developed by the municipal stakeholders (Seher et al. 2016). “This is a strong indicator for effectiveness as the agreement about cost allocation is crucial for establishing intermunicipal co-operation in flood risk management” (p. 62).

Savenije (1996) clearly sees a connection between creating awareness in citizens and the formation of awareness in politicians – if it is high in citizens, it is also high in politicians. This can be achieved e.g. through communication, education and reinforced civil participation being very important tools for a functioning water resources management (Savenije. 1996). This is the reason why the integration of the public was of great importance from the beginning on. People are getting informed about measures that are planned or carried out by the co-operation but also learn about measures that can be taken privately for being self-responsible and therefore creating better individual protection.

Small, non-structural measures taken downstream are a very effective way for adaptation. Since there is not enough space available for retention purposes in the more densely populated areas along the Aist, small measures are the only option of mitigating the damages. Furthermore, with the introduction of the European Floods Directive in 2007, participation, as another form of adaptation, was becoming more important and was regarded as crucial from the beginning of the establishment of the co-operation. In general, since the EU- Floods Directive, planning is done in a more holistic way, interdisciplinary and inter-locally, and the water ecology now has to be integrated in the planning of projects as a permanent factor. In this inter-local co-operation, water ecology, the sustainable development of the rivers and streams as well as the condition of the ground water are very important factors to consider in the planning and implementation of flood mitigation measures (Josef Lindner. June 6th, 2013).

### 7.1.3 Upstream and downstream co-operation in flood risk management

Stakeholder participation in decision-making is widely recognized as a very important component in the successful management of water resources (Margerum. 1995; Medema et al. 2016). This is effectively realized in the association along the Aist, as the interviewees declare and according to the radio interview with Josef Lindner in 2013, 40 public events were organized to inform the stakeholders and the public. Although, according to Seher et al. (2016), the civil initiative was responsible for the public to get more attention and made it possible for the public to participate as it is handled now, the official information is that one focus of the association was an interdisciplinary approach since day one (Hochwasserschutzverband Aist. n.d.a).

A large proximity as it is described by Thaler et al. (2016) can be seen in this co-operation. This is one indicator that this inter-local co-operation approach at the Aist can be transferred into other examples of catchment-based flood risk management. There exists social/relational proximity, as there is a variety of personal linkages (in rural areas it is easier to have a large social proximity because most people are familiar with each other or even related) and common experiences that tie together plus spatial proximity is evident, in form of short distances between the municipalities in the relatively small catchment (650 km²). The common legal framework is to be considered as institutional proximity, and as residents mostly accept and understand the risk mitigation purposes of structural but also non-structural measures, this can be seen as technological proximity (for more detail see section 4.1.3).

Landowners play a crucial role in the implementation of measures against floods. At first, they are confronted in negotiations about their land. It seems to me however, that there could be a better communication between the authorities and the affected landowners, since most landowners first reaction towards the idea of having flood defence structures on their land is negatively connoted. Either they have been given wrong information about what this could mean for them, or the compensation is too little and of no inducement.

A strong solidarity can be found between the stakeholders in the catchment of the river Aist, as it was confirmed by the interviewees. This could be due to socio-economic linkages between upstream and downstream municipalities and shared experiences with floods, which they have experienced for a long time already (Seher et al. 2016).

In many co-operation approaches a common problem is the communication between authorities and the affected public. “This gap between prescription and practice is sometimes attributed to politics” (Blomquist et al. 2005, p. 101). The gap which is addressed here is a gap between policy-making at regional level and implementation at local-level (Chen. 2008). In case of the inter-local co-operation along the Aist this does not seem to be of any problem (any more). Managing natural resources, as well as linked social and natural processes always have to deal with complexity, uncertainty and variation (Medema et al. 2008). However, in case of the Aist, the co-operation seems to be a suitable governance strategy. The upstream-downstream relationship is good and according to Seher at al. (2016) it fulfils the characteristics of a suitable instrument for their region; a catchment-based flood protection and cost-allocation scheme were developed, and flood risk is mitigated in the highly vulnerable downstream part of the catchment.

# Chapter 8
# Conclusion

With the help of the practical part I have found that the co-operation between municipalities in the catchment area of the Aist works well and it even is a model which could be applied in other catchments under the consideration that every catchment has its own characteristics to respect. However, the goal to protect the catchment from flood events with a 100-year reoccurrence is not fully reached yet. A change in strategy since the inter-local co-operation was established took place, which is on the one hand because of the introduction of the European Floods directive in 2007, demanding participation of the public, which was then integrated into the goals of the association. On the other hand, there was a change in the protection goal of the catchment, due to the fact that a flood defence scheme for a 300 to 500-year reoccurrence (which would have been necessary after the last devastating event) is not financed by the state of Austria and therefore, it had to be reduced to a 100-year reoccurrence protection scheme.

## 8.1 Answering the research questions

The research questions presented in the first chapter of this thesis can now be answered as follows:

1. Is the co-operation between the municipalities in the catchment area of the Aist successful? Yes.

2. Was the goal, to protect the catchment from flood events with a 100-year reoccurrence, reached? Partly, yes.

3. Was there a change in strategy since the inter-local co-operation was established? Yes.

4. Did difficulties in reaching the goal arise? Yes.

## 8.2 Limitations of the study

If possible, it is better to carry out an interview earlier or later in the year, since from the month July on at least in Austria, people are leaving work for their summer holidays and some interviewees were either still on holidays or I caught them just before they were taking their holidays. This is probably also the reason why I had to call some of the experts again to ask them to answer my questionnaire, as people have to finish their work projects before they leave for their holiday and tend to forget additional tasks, which are not that relevant for them. Generally speaking, also the mood of people is better after their holidays, they are more relaxed, and one could therefore argue that it would have been easier for the interviewees to find time and the willingness to answer my questions. But I was lucky anyway.

Two out of the chosen seven experts were not able to answer the questions I posed due to different reasons. However, they both told me that they were interested in the topic I am writing about and even offered their help if I needed anything else for my thesis which lies in their field of competence. One of the mayors referred to the spokesman of the union of municipalities whom I was questioning anyway. The mayor from another member municipality also referred to the chairman of the association and could not answer the questions since he took office only at the end of 2015 and is focussed on different topics at work.

## 8.3 Outlook

In the future, for the topic of flood risk management Wagener et al. (2010) recommend that a primary characteristic of hydrological research has to be, not only inter-disciplinary but cross-disciplinary research in order to really grasp the environment in the interaction with humans as a "holistic entity" (p. 6). In Austria, some small communities are still cautious about what inter-local partnerships might entail. Some of them are afraid of losing their identity and independency of self-government. However, large downstream communities are still more willing to be part of a co-operation, than upstream communities. This is mainly due to economic reasons and the prospect of getting flood protection without having to sacrifice too much land or money (Thaler et al. 2016). A paradigm shift in hydrology has already commenced, but has to develop even further so that the extent of human activities on the environment can be better understood and implications can be predicted (Montanari et al. 2013; Wagener et al. 2010). With the use of digital cameras and cell phone signals hydrological data and relevant information for the mitigation of flood events can be retrieved (Montanari et al. 2013) in sciences but this information could also be useful for private individuals. We will see what other interesting perspectives are going to be created with the continuous technological development.

Research initiatives of the International Association of Hydrological Sciences (IAHS) have been established to motivate and educate young researchers and to further develop hydrological sciences, in an integrative manner. In the future it will become even more important to see the mutual relationship between water and society, due to the increasing societies worldwide (Montanari et al. 2013). In case of the Aist catchment this trend is already being observed and new ways of handling floods need to be further developed.

Land-use regulations, as well as hazard zones, plus the re-naturalization of river stretches can be very helpful instruments in minimizing the hazard along rivers. Here institutions play an important role in the realization of such legal tools (Fuchs. 2009; Thaler et al. 2016).

Another factor can be rainwater drainage. In urban areas rainwater drainage is necessary for a delayed flood wave. At the same time, it belongs to one of the seven urban ecosystems that were identified by Bolund et al. (1999). Ecosystem services have a substantial impact on the quality of life of people and should be more integrated in land-use planning in general (Roberts et al. 2015). However, in case of already populated catchment areas the only real possibility of mitigating the hazard of flooding is through non-structural measures which can only be effective to a certain extent. A mix of structural and non-structural measures plus the implementation of legal tools, creates the best flood defence strategy (Cannon. 1994; Consoer et al. 2018; Di Baldassarre et al. 2013).

A further idea is the cultivation of certain agricultural plants, which in case of flooding, either can take up a lot of water or are able to still survive with a high water level (Shiva et al. 2005). These could be grown in retention areas, so the farmers do not have to face a crop failure and do not miss out on their income, which many of the farmers in the Aist catchment are dependent upon. Alternatively, forest areas could fulfil the same purpose to retain water and delay the flood wave downstream. Trees can take up more water than crops are able to, plus their roots create space in the soil where water can drain into (Patt et al. 2001; The Woodland Trust. 2014).

In order to create even more awareness for flood risk in the Aist catchment, signs could be put up by public authorities at sites that are at risk, to explain in an understandable way, what has happened and what could happen again in the future. The most difficult thing, to my mind, is the process of reaching people. If information events are organized but people either do not know about it or are not interested, then the information which could be really useful will not reach them. Another idea would be radio shows dealing with the topic of flooding. The downside to this however is that many people do not listen to the radio, since other means of entertainment are more attractive. Mainly elderly people still listen to the public radio and they are not the only ones being affected by floods. Also, the younger generations need to be aware what impacts this hazard can have and what they personally can do to protect themselves or at least minimize the damages.

In a time where individualization is very popular and although people are highly connected with each other all over the world with all kinds of different media that is available today, it seems to me that people are separated in their "real lives". Creating communities that interact with each other, have common activities and foster communication is one major tool which would help creating more resilient communities. As Fernandez-Gimenez et al. (2008) and Seebauer et al. (2018) state, trust is extremely important when it comes to communities which are collaborating successfully. Being familiar with members of the community or group creates a good feeling and therefore people have a higher willingness to create something or work together as a group. To foster communication and finding ways of integrating the younger generations could be very valuable for the purpose of reducing the hazard from flood events in the Aist catchment.

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