RISK AND RESILIENCE REPORT

Mapping Social Vulnerability in Switzerland

A pilot study on Flooding in Zürich

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Risk and Resilience Team
Center for Security Studies (CSS), ETH Zürich

Commissioned by the Federal Office for Civil Protection (FOCP)

CSS
ETH Zurich

ETH zürich

Contact:
Center for Security Studies
Haldeneggsteig 4
ETH Zurich
CH-8092 Zurich
Switzerland
Tel.: +41-44-632 40 25
css@sipo.gess.ethz.ch
www.css.ethz.ch

Client: Federal Office for Civil Protection (FOCP)

FOCP project supervision: Stefan Brem, Head of Risk Analysis and Research Coordination

Analysis prepared by: Center for Security Studies (CSS), ETH Zurich

ETH-CSS project management: Tim Prior, Head of the Risk and Resilience Research Group; Oliver Thränert, Head of Think Tank

Authors: Tim Prior, Florian Roth, Linda Maduz, Flavia Scafetti.

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Executive Summary

Natural and anthropogenic hazards cause significant damages globally, destroying lives, health, property, and disturbing social, economic and ecological systems. Risk maps have become a central element in modern disaster risk management research and practice, helping to reduce these impacts. Risk maps combine three types of information: information on the hazard; how people and assets are exposed; and, an estimate of how vulnerable exposed assets (and people) are relative to the hazard in question. While structural vulnerability is typically addressed in this model, social vulnerability is often not considered.

Improving the precision of social vulnerability estimates for accurate risk maps is important to properly understand risk to society. This report details a pilot study that sought to understand and map social vulnerability to flood hazard in the city of Zürich. We develop a theoretical basis, and practical methodology to identify key factors of social vulnerability and their interdependencies. These social characteristics are mapped to identify 'hotspots' of social vulnerability in the city. Social data for the project were supplied by the City of Zürich. Flood mapping data were supplied to the research team by TK Consult AG on behalf of the Canton of Zürich.

Unlike most previous research on social vulnerability to hazards, this report combines social factors that have been found to influence and exaggerate social vulnerability to hazards. This approach captures the interdependence of these social factors, providing a more realistic representation of the complexity of social systems. In addition, the research team sought to align the selection of social vulnerability factor 'categories' with the Swiss Integrated Disaster Risk Management (IDRM) cycle, ensuring that results from the mapping results could be directly related to organizational civil protection actions. All work was conducted at the Statistical Zone level, within which numbers of households meeting the social vulnerability category conditions were counted.

Three social vulnerability categories were mapped. Each group describes a household type, and reflects an issue that must be addressed by Swiss civil protection organizations in the context of the IDRM cycle. The first category were households inhabited by elderly women (≥80 years) living alone, and this category aimed to reflect a social group that can be difficult to evacuate in the case of a flood. The second household type were those where all members of the household were newly arrived in the city, and did not have a long-term residence permit. This category reflects a group with potentially low critical awareness of flood risk. The last category included single mother households, where the income was low. These households have lower capacity to cope with a hazard.

In all cases, the team was able to identify clear differences in the distribution of households falling into the three social vulnerability categories. In the contexts of the evacuation group (elderly women, alone) and the coping capacity group (single mothers, low income) the north of the city was particularly important. No discernable pattern was evident from the risk awareness category (newly arrived, non-resident). From a civil protection perspective, none of the identified hotspot areas were located in areas likely to be impacted by a 300 year flooding event in the City of Zürich.

Overall, this pilot study has demonstrated that mapping social vulnerability is a useful practice to complement existing integrated risk management activities. Three points are particularly important.

a) Social vulnerability exists in a wealthy city like Zürich, and it can be characterized interdependently (formulated in this report as a social vulnerability category) from several social factors.
b) Second, the project has demonstrated that mapping social vulnerability categories is possible and practical. The approach takes adds a fundamental facet that can help researchers and civil protection officials to locate pockets of social vulnerability in Switzerland..
c) Most importantly from a civil protection perspective, mapping social vulnerability can support localized risk communication, household-level preparedness, help to benchmark levels of vulnerability, and can inform spatial planning.

The project has demonstrated the ease (when data is available) of assessing and mapping social vulnerability in Zürich. At the same time, the results of the study highlight the value of analyzing social vulnerability for disaster management research and practice beyond the specific city context. If these assessments can be incorporated into existing risk maps, then social vulnerabilities could prospectively also be addressed in established risk analysis processes in Switzerland and elsewhere, contributing to overall societal resilience.

1 Introduction

Every year, natural and anthropogenic hazards cause significant damages globally. They destroy human lives, health, property, and disturb social, economic and ecological systems. Risk maps have become a central element in modern disaster risk management research and practice, helping to reduce these impacts. Risk maps combine three types of information: 1) where the hazard exists, 2) what is exposed to the hazard (physical presence of valuable assets), and 3) an estimate of how vulnerable (capacity to resist the effects of the hazard) exposed assets are relative to the hazard in question. The relationship between hazard, exposure, and vulnerability has been termed the 'risk triangle' (Handmer 2003).

Within this risk triangle, vulnerability of people is a weak link. The conceptual understanding and practical analysis of the hazard and exposure of physical and non-physical assets has dramatically advanced in recent years. However, vulnerability is assessed using rough estimates, focused typically on the physical vulnerability of buildings and infrastructure (BMI 2009; BABS 2015). Social aspects of vulnerability are mostly overlooked, even though social factors have an indisputable influence on the severity of a disaster (Quarantelli 1990).

The concept of social vulnerability has received close attention in disaster studies in recent years, though its application in practice is still in its infancy in most countries' disaster management activities. Improving the precision of social vulnerability estimates for accurate risk maps is important to properly understand risk to society. In fact, it is the social aspect of a hazard that defines a disaster. Unfortunately, social vulnerabilty is still often considered to be a problem of underdeveloped and developing countries, where poverty and inequaltiy prevent elements of the population lack key capabilities to prevent and cope with hazards (UN 2015, p.10).

Indeed, localized social vulnerabilities can also lead to more significant disasters in developed countries (Cutter 2002), and the US experience of Hurricane Katrina provides a perfect example of this (Haque and Etkin 2007). The example points to the fact that in highly developed countries like Switzerland, the prospective existence of disadvantaged social groups, likely to suffer disproportionally from hazards, means that special attention from disaster management agencies should be directed at understanding vulnerability and its implications with respect to the way people and communities respond to and recover from hazard events. Here, again, it is important to de-couple social vulnerability from the notion that it is completely dependent on the economic conditions of a community, a household, or an individual.

Knowledge of the factors influencing society's susceptibility to hazards remains very patchy (Tapsell 2010, p. 2). Most basically, understanding what social vulnerability is, is fundamental. Does it vary between hazards (natural, social, technical)? How do factors of vulnerability interact? Where do the socially vulnerable live? Are socially vulnerable groups geographically extensive? Can we develop a picture of why these groups become vulnerable? How do they interact with the environment around them?

1.1 Aims and Scope of Report

How can vulnerability be measured, and how can it be reduced? Do civil protection organisations need to reduce vulnerability, or is it sufficient to know where vulnerability exists, and what can be done to help these groups to adapt to potential hazards?

In Switzerland, these questions have remained largely unanswered. In 2010, the Center for Security Studies (CSS) at ETH Zürich conducted a first examination of social vulnerability in Switzerland, focusing on the 2005 flood events in several parts of the country (Bara, 2010a; Bara, 2010b). The study found that while Switzerland is among the most highly developed countries in the world, social vulnerability nevertheless exists. The existence of pockets of social vulnerability translate to a heightened risk of disaster for those groups, and inhibits recovery.

Building on these findings, the present report aims to deepen our understanding of social vulnerability in the Swiss context. Among other elements, it examines the ways social dynamics, urbanization, immigration, and changes in the labor market might present challenges for the mitigation of disaster risk in Switzerland. It first explores the nature of risk and the role of vulnerability (social and structural) in the risk triangle, providing a conceptual basis for the necessity of understanding and mapping social vulnerability in the context of hazards. We develop a theoretical basis from which to identify key factors of social vulnerability and their interdependencies. We put this theory to the test by focusing on social vulnerability to flood hazard in the city of Zürich. We identify several geographical 'hotspots' of social vulnerability in the city, adding value to existing risk maps for Zürich. The authors envision that this information can be used to support disaster management planning at a variety of points on an Integrated Disaster Management Cycle, and these implications and applications are detailed. The study aims to enrich current approaches to disaster risk management in Switzerland and beyond

This report is a pilot study. The authors have limited the extent of the examination in this work in order to demonstrate ease and utility of mapping social vulnerability. We focus on a small number of social vulnerabiltiy factors, one natural hazard, and examine a restricted geographic area (Zürich city). As a result, the explanatory power of this assessment is naturally limited geographically and in terms of hazard types. However, the work is demonstrative of a simple and practical methodology that makes use of several of the rich data sources that have become available in recent years to

yield significant advantages for civil protection professions in identifying and locating elements of the population that could benefit from targeted support in preparing for and responding to hazard events.

1.2 Structure of the Document

The report is structured in seven sections. Following this brief introduction, the concept of vulnerability is introduced, specifically in relation to the terms of risk, hazard, exposure, resilience, and in relation to the Integrated Disaster Risk Management process. The various dimensions of vulnerability are also examined, with particular focus on the social dimension of vulnerability. Section three explores a selection of exisiting approaches and methodologies to identify and analyze vulnerable social groups. It brings an international perspective to the assessment of social vulnerability, and presents a case for examining social vulnerability in an interdependent manner, influenced various by combincations of interacting social characteristics. Section four focusses specifically on understanding how to analyse social vulnerability in Switzerland based on existing work conducted by the CSS. We identify important social vulnerability indicators, and describe how these might be drawn together to reflect important social aspects of the Swiss disaster management cycle. Section five presents the methodology chosen in this study. It discusses the choice of Zürich as the study area and why the analysis is focused on flood hazards. Further, it describes combinations of social characteristics used as proxies for elements in the disaster management cycle. Section six presents the results of the pilot study on social vulnerability in the city of Zürich. It shows how the flood hazard and social vulnerability are distributed across the city area, pointing to a number of geographical hotspots of social vulnerability. Finally, the implications of the analysis and are discussed in the concluding section seven. We critically discuss the methodology used, the practical application of social vulnerability mapping in Switzerland, and the integration of such a technique in existing hazard analysis procesess. We also identify potential data sources for future use.

2 Vulnerability: Definitions, Conceptions, Practices

Before examining vulnerability in detail, it is necessary to clarify the connections between vulnerability and related concepts. In particular, the links between vulnerability and the broader notion of risk, and between vulnerability and resilience. In recent years, the concepts of risk and resilience have become central in scholary debates and policy discourse on disaster management, which now typically integrates a diverse range of organisations, processes, strategies, actions, and capacities in a systematic and cyclic manner.

In order not to get distracted by conceptual ambiguity, the relationships between these interdependent concepts are important to consider when discussing and defining vulnerability, and in the context of their practical application in disaster management. Additionally, this section sketches out the key dimensions of vulnerability that loosely align with the different branches of vulnerability research.

2.1 Vulnerability as a component of risk

The concept of vulnerability is strongly related to that of risk and risk management. Disaster risk management practice mostly follows an engineering approach to risk. In this tradition, risk is generally understood as the combination of the probability of an event and its negative consequences (UNISDR 2016). This definition is highly useful in many circumstances, particularly because it allows to compare and prioritize different disaster scenarios. At the same time, it is less suitable for understanding the structural conditions that determine the severity of the consequences of disasters. To this end, an alternative conception of risk is often employed. Accordingly, whether someone or something is at risk can be seen as function of the relevant hazard(s), the exposure of a given entity to these hazards and finally the entity's vulnerability (Handmer 2003).

Hazards, exposure and vulnerability together form the three components of the so-called 'risk triangle' depicted in Figure 1. Altering any side of the triangle - hazard, exposure or vulnerability, influences the risk. For example, if exposure increases, the likelihood of damage from a stable hazard will increase; likewise, if social or structural vulnerabilities are reduced in a stable hazard environment, then the likelihood of damage caused by the hazard decreases.

Figure 1: Risk triangle, based on Handmer 2003, p. 56

Hazards are defined as events or processes with the potential to disrupt society, having natural or anthropogenic origins. When hazards interact with society, causing loss of life and property, they might become *disasters* – hazardous events that have a major impact on a social system (Prior, 2013:17).

People and property must be exposed to hazards for these events to become disasters. *Exposure* can be defined as 'the presence of people, livelihoods, environmental services and resources, infrastructure, or economic, social or cultural assets in place that could be adversely affected' (IPCC 2012). Knowledge of exposure helps to identify entities at risk depending on the physical location of the communities or assets, land management and settlement development, and the societal structure in any given territory.

Vulnerability is the final component of the risk triangle. The word vulnerability is derived from the Latin term *vulnerā(re)* – to wound. In the context of disaster risk, the concept is used with respect to individuals, societies, ecosystems, technological systems, and a range of other social, structural, cultural, and ecological units (Dow, 1992:420). In recent years, the concept has attracted increasing scholarly attention, yet often the use of the concept is rather vague, complicating its empirical observation (Birkmann 2013:20,).

Influenced by different schools of thought and fields of application, there exist countless alternative definitions of vulnerability. For the purpose of this study, we follow the definition given by the United Nations Office for Disaster Risk Reduction (UNISDR). The UNISDR identifies vulnerability as "the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard" (UNISDR 2016). As this definition highlights, vulnerability focuses on an entity's susceptibility to a hazard, *i.e.* the intrinsic deficiencies of the entity that determine the likelihood it experiences harm or loss in the event of a hazard. Accordingly, vulnerability exists when exposure cannot be compensated by coping or adaptive capacities (Chambers, 1989; UNEP, 2002; Feldbrügge and von Braunn, 2002; Handmer, 2012). Vulnerability also exists if the effects of a hazard cannot be mitigated or prevented. Coping reflects the ability of the entity to protect itself on the short term through inherent protective mechanisms; adaptive capacity expresses an entity's ability to learn and change in a long-term process (Smit and Wandel 2006:287) in response to external pressure on the entity from the systemic character of the system in question.

2.2 Vulnerability and resilience

Capacities to cope and to adapt to hazards link vulnerability to the concept of resilience. The term resilience (from the Latin word *resilire,* meaning "to

bounce back") is defined by the UNISDR as "the capacity of a system to resist or to change in order that it might obtain an acceptable level of functioning and structure." In a social system, this definition highlights the importance that the system is "capable of organizing itself" and has "the ability to increase its capacity for learning and adaptation," including the ability to recover from a disaster'' (UNISDR 2016[1]).

A growing body of literature seeks to identify the linkages between the notions of vulnerability and resilience. Often resilience and vulnerability are thought to be conversely to each other: the more resilient a society is, the less vulnerable it would be if faced by an adverse event (Gallopin 2006:301). While this may be the case in some contexts, it is not always so. Instead, the concepts can be differentiated in terms of the level of analysis: while resilience primarily refers to characteristics of systems as a whole, vulnerability is focused on the differences among the system's components (Bara 2010b, p. 239). For instance, community resilience is determined by the relationship between people rather than a sum of each individual's resilience, because combining the resilience of individuals does not guarantee a resilient community. Also, a community might be resilient as a whole, but still comprise vulnerable categories, whose needs might not be met by the capacities held at the community level. In this sense, emphasis is put on the notion of social capital and on the extent it shapes human relationships and interactions (for instance, the possibility to seek help from friends or relatives).

2.3 Dimensions of vulnerability

Despite the ambiguity of vulnerability among academics and practitioners, there is consistent agreement with respect to the dimensions that vulnerability encompasses. Birkmann (2013:26) differentiates between four dimensions of vulnerability:

Economic vulnerability: refers to the susceptibility of an economic system. On the macroeconomic level, this includes market regulation and political economy. At a microeconomic level, economic vulnerability primarily relates to occupational and livelihood patterns, and economic assets of at-risk households or individuals.

Environmental vulnerability: refers to how peoples' livelihoods, the system services and functions, or other societal dimensions can be adversely affected by degradation of the environment, which could lead to an increased degree of exposure to hazards.

Institutional vulnerability: refers to governance constraints that might lead to a lack of capacity to effectively respond to a hazard, or to assure adequate coordination among the main government and non-government bodies in charge of emergency preparedness, response and recovery.

Social vulnerability: refers to the susceptibility of human beings to harm in their physical and social environments. The concept of social vulnerability focuses on the processes and structures in society that might negatively affect the likelihood that "some socially defined group in society will suffer disproportionally" from a hazard (Handmer and Wisner, 1999). As Hewitt (1997) points out, social vulnerability exists where "people's capacities to avoid, mitigate, resist and recover from harmful events are undermined by forces of social organization." These are characteristics of the social system existing before, and generally independent of, the occurrence of a hazardous event, which increases the weaknesses of a society to the hazard's impacts. According to Handmer (2012:162) vulnerabilities "arise from circumstances of people's everyday life," as existing pressures and challenges influence peoples' capacity to cope and adapt (Paton *et al.,* 2008; Eriksen and Gill, 2010). Therefore, social vulnerability is often considered to be a 'human-induced' situation (Chackraborti *et al.*, 2005). Consequently, the concept is strongly focused on social inequality.

2.4 Vulnerability in Current Disaster Management Practice

In most developed countries, civil protection practices are based on so-called Integrated Disaster Risk Management (IDRM) processes. The IDRM process stretches from prevention and preparation before an event occurs, to the response phase involving evacuation and emergency response, and the recovery phase of analysis and reconstruction. It is based on the continuous analysis of risks as well as evaluation and, if necessary, adaptation of current practices to suit social, political, cultural, or environmental changes. In order to reduce disaster risks, authorities can address any dimension of the risk triangle Aven and Renn (2010) note that "an effective disaster risk management that is convergent with other public and private policies seeks to reduce risk, exposure and vulnerability by filling gaps in order to avoid or reduce human casualty and economic losses caused by disasters."

Actions to reduce hazards and exposure are typically situated at the preventive step of the IDRM process. This may include, for example, the prohibition of hazardous chemical materials or spatial planning strategies that limit human settlings in hazard-prone areas. By contrast, efforts to reduce vulnerability can take place at every step of the risk management cycle. In the context of prevention, tackling vulnerability may mean strengthening a fragile system (*e.g.* infrastructure or social system), thereby decreasing the likelihood of severe failures. At the stages of preparedness, response and recovery, essentially all measures are aimed at decreasing vulnerability, and less hazards or exposure. For instance, in terms of preparedness, training or disaster family plans may be effective ways to mitigate the impact of disaster events on society and thereby

[1] https://www.unisdr.org/we/inform/terminology

reduce vulnerability. In the response phase, effective emergency services are key assets for coping with disaster.

Nonetheless, the concept of vulnerability is only slowly finding its way into disaster management strategies. In this context, it is mostly understood in structural terms (locations of socially important structures, like schools, hospitals, *etc*.) (BABS, 2015a; BBK, 2016). A case in point is the domain of critical infrastructures (BBK, 2002; BMI, 2009; BABS, 2015). Consequently, risk analyses and risk maps, which are typically conducted or developed by national and sub-national civil protection agencies, and that form the central basis of modern disaster management systems, are predominantly focused on the identification of hazards, exposure, and structural vulnerabilities.

By contrast, disaster management strategies often overlook social aspects of vulnerability. Most debates on the vulnerability of social groups have traditionally been led in the context of developing countries. Humanitarian aid workers and development professionals are particularly active in the field of vulnerability research (Darcy, 2003, p. 7). In consequence, attempts to analyze, and ultimately reduce social vulnerabilities, have proliferated in modern development, humanitarian and disaster risk reduction strategies for underdeveloped regions, particularly in South/Southeast Asia, Africa and South America (Tapsell, 2010, p. 2).

Attention is slowly moving towards social vulnerability in developed contexts, most notably in the United States. Much of this interest has been triggered by the case of Hurricane Katrina, which devastated New Orleans in 2005. About 1800 inhabitants lost their lives even though a mandatory evacuation was ordered the day before the hurricane struck. Subsequent analyses have shown that victims were mainly elderly people, the poor, homeless, or from households not owning a car. Furthermore, because the hurricane made landfall at the end of the month, salaries had not been paid and many poor residents had no means to leave the city (Cutter, 2009). Research since this time has demonstrated how social vulnerability is also important in disaster management in developed countries. This realization has encouraged a growing stream of research, also in the European context (for example, Steinführer and Kuhlicke, 2007; Fekete, 2009). Following this trend, in recent years disaster management and emergency response policies have begun to turn to the challenges of addressing vulnerable social groups, particularly at the local level. For example, the German state of Hesse has begun to establish an early-warning system for heat waves that specifically targets population groups that are expected to be particularly vulnerable to this type of hazard (Grewe and Blättner, 2012).[2]

However, despite the growing interest in the topic, identifying social vulnerability is a complicated endeavor. Notably, in countries where extreme vulnerabilities are less evident, as in the developing world, and where social inequalities are usually addressed with welfare state services provision, it is more difficult to determine the social groups most likely to be affected by the occurrence of a hazard (Bara, 2010b). Further, processes of individualization might complicate the analysis of social vulnerability (Steinführer and Kuhlicke, 2007, p. 119).

While in modern societies the clear division of labor and wealth distribution permits an easy distinction between excluded groups or ‘classes’, social inequalities are becoming increasingly unpredictable, varying across space and time (Beck, 1992, p. 87). Moreover, even when characteristics that define a vulnerable group can be identified in one case, they may not be transferable to other contexts. In other words, there exists no one-size-fits-all approach to determining vulnerability, and models or indicators should always reflect the specific social context and purpose of the analysis.

The following section introduces a number of conceptions that help to understand and classify the different existing approaches that can be employed for the analysis of social vulnerability.

[2] Also in Switzerland, efforts to address groups vulnerable to heat waves haven been undertaken, even though they are still in their early stages (Swiss TPH 2015).

3 International Perspectives on Analyzing Social Vulnerability

A broad variety of frameworks and approaches for assessing vulnerability exist. By drawing on international experiences from reported research, this section explores the variety of perspectives of social vulnerability. Specific focus is placed on studies that have examined the vulnerabilities of social groups in developed contexts.

The section reviews eight research projects from Australia, Germany, Italy, Romania, the United Kingdom and the United States. The different perspectives found in this research are systematized according to four criteria: the level of analysis, influencing factors; the typology of hazard; and assessment methodologies. Within the broader development context, the section considers different national contexts, scales and academic disciplines: from national (relying on loss and census data, and requiring a high degree of aggregation of household data); to the community level, with a focus on the directly exposed population (which requires the collection of qualitative information to evaluate risk perception and social response capacity) (see Table 1).

3.1 Level of Analysis

Social vulnerabilities can be observed at very different levels. Susceptibility to suffer from hazards can differ between national social systems or regions in the same country, but also between neighboring communities, or even between members of a family. To explore the relevance of these differences, researchers have examined the characteristics of social vulnerability across analytical levels.

The choice of the spatial level is important for the research process, as it influences both the data collection methodology and analytical data aggregation. Extensive data aggregation is particularly common for studies on national or regional levels (Cutter, 2010; Armas, 2013; Frigerio, 2016), because the quantity of data can be difficult to manage and aggregation makes it more managable. In contrast, studies on the community level, often refer to qualitative approaches, typically based on in depth interviews and group discussions (Handmer, 2012).

While such approaches can be valuable for identifying local vulnerabilities, they often draw on very specific instruments, making wider comparisons between different studies hard. Choosing the right scale of analysis for the context under examination is important. For example, aggregating data on a regional level might overlook important vulnerabilities that might otherwise only be observable at a smaller spatial scale – the suburb level, for instance. Using inappropriate spatial scales could yield incorrect conclusions, because differences on lower levels are overlooked (Clark, 1976:429).

3.2 Factors Influencing Social Vulnerability

Social vulnerability has been analyzed from different theoretical angles, each building on specific research traditions and epistemologies. For the sake of simplification, we briefly outline three main approaches to the study of social vulnerability: Economic, socio-demographic, and cultural perspectives.

3.2.1 Economic aspects

Generally, studies following this perspective share an interest in the links between the economic attributes of social groups and their vulnerability to hazards (Lundgren, 2012). In this respect, some conceptual frameworks explicitly define the thematic areas to account for, and focus on, issues concerning monetary-related indicators and employment status (Frigerio, 2016; Cutter *et al.*, 2003, 2010; Fekete, 2009), property ownership, and housing quality (Armas, 2013). Emphasis is also given to indicators related to individuals' financial losses from previous disasters and the availability of savings that can be used if necessary (Bara, 2010b).

3.2.2 Socio-demographic aspects

Following this perspective, social vulnerability is strongly connected to the establishment and composition of social relationships. Studies undertaken from this perspective typically investigate the main characteristics of the study population (age, family structure, and intangible drivers like community social networks (Kuhlicke, 2011; Handmer, 2012) considered to be factors triggering community capacity of response.

The concept of social capital has been an important feature in research that examines the socio-demographic character of hazard exposed communites (Pelling and High (2005:312). In his research, Bourdieu (1986) defined social capital as 'the aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintance or recognition'. Social capital creates value through the 'features of social organization, such as trust, norms, and networks that can improve the efficiency of society by facilitating coordinated action' (Putnam, 1993:2). To some extent, the social ties arising from everyday interactions are an integral component of adaptation processes, enabling people to cooperate and act collectively (Adger 2003:401). The link between social capital and adaptation is also confirmed by studies that find positive effects of social capital on the capacity of response of communities during and in the aftermath of natural disasters (Pelling, 2005:315; Cutter, Borluf and Shirley 2003:245; Nakagawa and Shaw, 2004:27; Prior and Eriksen, 2013).

3.2.3 Cultural aspects

Research from this perspective focus on the connections between vulnerability and cultural aspects associated with the community. Cultural elements are typically understood to be the community's cumulative deposit of knowledge, experiences and beliefs. Attention is put on the heritage of previous disaster experience and peoples' perception of risk (Kuhlicke *et al.*, 2011:803; Handmer *et al.*, 2012:167; De Marchi, 2012:322), on the difficulties encountered by individuals who are not able to speak the local language (Frigerio *et al.*, 2016; Cutter, 2003), and on the way gender roles determine different responses in coping with and adjusting to a disaster (Eriksen, 2014).

3.3 Typology of Hazard

Most studies of social vulnerability focus on the susceptibility of social groups confronted with a single hazard or a set of hazards that are geographically relevant. Depending on the context of analysis, and given the specificity of social vulnerability, approaches to measuring the characteristic often refer to the main natural hazards of the study area (Armas, 2013; Fekete, 2009). Reflecting common disaster management practice, at the center of attention are most often seasonal natural hazards (such as floods, droughts or bushfires), while the impact of rarer events is usually less extensively considered (Cutter, 2003; Frigerio, 2016).

Alternatively, some research aims to identify generic social vulnerability. According to Handmer, social vulnerability, particularly on the community level, should be understood as a set of attributes that are not directly tied to specific hazards (Handmer 2003).

3.4 Existing Methodologies in Vulnerability Assessments

The choice of data collection methods and their respective sources depends upon the framework of the analysis, time, and resource constraints. The current debate regarding the appropriateness of social sciences methodologies is significantly diversified, offering several examples of a range of qualitative, quantitative and mixed data collection tools. This section examines typical data sources.

3.4.1 Loss Data

Loss data from previous disasters is a valuable source providing information on material losses. For instance, material losses like damage to houses, infrastructure, lifelines, agriculture and other economic-related losses; and human losses like injury, homelessness, disappearance, evacuation and other effects. These historical data can provide a comprehensive picture of direct, indirect and intangible losses, the follow-on effects on social groups, long-term socio-economic impact (for instance arising from the loss of trust), as well as information on relevant local knowledge and traditional adaptation strategies. While these data have proven useful in the case of seasonal natural hazards, being expected both in their timing and extent, they might not be as helpful when dealing with extraordinary and unforeseen events for which no previous record exists.

3.4.2 Structural Data (Census data)

Based on statistical analysis of past disaster events, structural data allow the identification of variables repeatedly associated with losses. Such data are usually easily available and up to date. They can provide reliable and comparable information and offer information related to a variety of social vulnerability domains. Moreover, given the key role of insurance as a primary strategy in loss recovery, insurance data could be used to identify those population groups that struggle to recover, and consequently suffer long-term effects. Problematically, this data is typically held by private companies, complicating its accessibility to researchers. Data might be provided at aggregated level and, therefore, implicate a significant loss of detail. Furthermore, operationalizing social vulnerability through a set of indicators might ignore its contextual dimension (De Marchi and Scolobig, 2012:317). Similarly, there is concern that some selected indicators might fail to capture the multidimensionality of vulnerability, and produce false positives or false negatives.

3.4.3 Self-perception of Vulnerability

Observational data of vulnerability related to personal condition, deprivation, and disadvantage comprise the more typical measures of vulnerability. However, intangible aspects shaping peoples' vulnerability like attitudes, awareness and agency (De Marchi *et al*. 2007, p. 333) can be explored to add an extralayer of depth to an understanding of vulnerability. Collecting this kind of data can be accomplished using community participatory tools like Focus Group Discussions and interviews. These qualitative methods have proven to be effective when deepening understandings about social dynamics, which might be overlooked if traditional quantitative methods are used alone. An important limitation of these tools is the fact that they tend to be more expensive and time consuming to deploy, restricting their large scale implementation. However, the importance of the investigation of subjective aspects of vulnerability reflects the demand for a measure able to describe a multifaceted and changing reality, adding the indispensable human aspect to the assessment. It is important to acknowledge, though, that the self-perceived vulnerability of individuals may not match a quantitative assessment of vulnerability (De Marchi and Scolobig, 2012, p. 323; Kuhlicke *et al.*, 2011, p. 803; Siegrist *et al.*, 2006, p. 974).

Table 1: Overview of perspectives in social vulnerability studies

Case Studies		Spatial Level	Factors Influencing Social Vulnerability	Typology of Hazards	Methodology and Data Basis
Frigerio and De Amicis, 2016	**Italy**	National	Social and Economic Vulnerability	Multi-Hazard Approach	Quantitative Approach: Italian National Institute for Statistics (ISTAT)
Armas and Garvis, 2013	**Romania**	City	Social and Economic Vulnerability, Housing Quality	Earthquake	Quantitative Approach: National Institute for Statistics (NIS)
Cutter *et al.*, 2003	**SoVI United States**	National	Social and Economic Vulnerability	Multi-Hazard	Quantitative Approach: United States Census Bureau
Cutter *et al.*, 2010	**US Southern States**	Regional	Social, Economic, Institutional and Infrastructure Resilience, Community Capital	Storms, Flood and Hurricanes	Quantitative Approach: National Data Sources
Fekete, 2009	**Germany**	County	Rural- Urban Differences, Socio-Economic Condition, Human Fragility	Flood	Quantitative Approach: Federal Statistical Office of Germany
Kuhlicke *et al.*, 2011	**Germany, Italy and UK**	Community	Social Networks, Disaster Experience	Flood	Mixed: Quantitative and Qualitative - Questionnaire Survey, Semi-Structured Interview, Focus Group Discussions and Analysis of Previous Survey
Whittaker *et al.*, 2012	**East Gippsland, Australia**	District	Social and Economic Vulnerability, Social Life and Coping Capacity	Bushfires	Qualitative: Archival Research, Semi structured Interview , Informal Discussion and Participant Observations
De Marchi and Scolobig, 2012	**Italy**	Community	Social Vulnerability at Individual and Institutional Level	Flood	Mixed: Qualitative analysis of existing sources, Key informants interview, Survey

3.5 Indicators of Social Vulnerability

One of the main challenges in the analysis of social vulnerability is the identification of appropriate indicators for the operationalization of the concept. Only with valid, reliable and objective empirical indicators can social vulnerability be adequately examined in the real world. A review of the literature in the field reveals that very different indicators are being employed to capture phenomena of, and trends in, social vulnerability. The choice of indicators is influenced by the specific purpose of the studies, the availability of data, but also by the theoretical perspective taken on social vulnerability. Based on the discussion in section 3.2, we concentrate on exploring indicators of social vulnerability that considers economic, socio-demographic, and cultural factors. Table 2 gives an overview of the various indicators used to date in research on social vulnerability.

3.5.1 Economic resources

From an economic perspective, the ability to resist hazard consequences in the short term and recover in the long-term from hazards impact is dependent on the material, financial, or informational resources that people have at their disposal. In this sense, the use of data related to the *economic status* and *employment* condition, information on *education,* and reliance on the welfare state provide valuable insights about who in the population is more or less vulnerable to hazard impacts. Socio-economic factors that might exacerbate vulnerability include:

- unemployment, under-employment or lack of job security;
- poverty;
- the lack of sufficient language skills necessary to understand relevant information;
- the lack of sufficient education to support the recovery process and assure future economic productivity.

The absence of these resources inevitably constrains individuals' coping and adaptive capacity. Among other issues, these factors often result in members of the population at risk either being under-insured, or lacking insurance altogether (Handmer, 2012:169).

Possible Indicators: Economic Status, Employment, Education;

Table 2: Indicators of social vulnerability in recent studies

Case Studies		Frigerio and De Amicis, 2016	Armas and Garvis, 2013	Lungren and Jonsson, 2012	Cutter *et al.*, 2010	Fekete, 2009	Handmer *et al.*, 2012
Social Vulnerability Indicator Groups		Italy	Romania	Sweden Review	US (8 Southern States)	Germany	Australia
Socio-Economic Domain	Employment and Economic Status	x	x	x	x	x	x
Socio-Demographic Domain	Household Composition	x		x		x	
	Age	x	x	x	x	x	x
	Health Status		x	x	x	x	x
	State Infrastructure and Welfare		x	x	x	x	x
	Social Networks			x	x		x
Cultural Domain	Gender Differences	x	x	x		x	x
	Ethnicity	x		x	x	x	
	Education	x	x	x	x	x	x
	Risk Perception			x			x

References: Cutter *et al.*, 2003; King and MacGregor, 2000; Kuhlicke *et al.*, 2011; Reid *et al.*, 2009, Holand *et al.*, 2011; Elstad, 1996; Morrow, 1999; Cutter *et al.*, 2003; Twigg, 2001; Downing and Patwardhan, 2004; Blaikie *et al.*, 2005; Collins and Bolin, 2009; Adger *et al.*, 2009, Lee, 2014; Dwyer *et al.*, 2004; King and MacGregor, 2000; Dwyer *et al.*, 2004.

3.5.2 Socio-demographic disadvantage

From a socio-demographic perspective, social vulnerability is not primarily linked to financial resources, but to non-economic characteristics of individuals, households and communities.

At the individual level, socio-demographic characteristics like age can increase susceptibility to hazards. For instance, c*hildren* and the *elderly* are susceptible because of their dependency on others. People with *reduced mobility*, other *physical incapacities*, or with *health conditions*, may also be more vulnerable. *Psychological illness* may also significantly affect the capacity to both respond and recover from a hazard event.

On the family level, the *household composition* might be a key element in identifying those families that might be unable to sustain the burdens and stress of hazard experience. For instance, in case of disaster, large families might have specific challenges to evacuate or find emergency housing. On the other hand, single person households may lack social support networks that could help them to deal with a variety of demands.

At the community level, the existence of strong *social networks* are often necessary to support the provision of material and emotional support (Bara, 2010a, p. 18). Unfortunately, social groups typically do not benefit equally from state services and charity programs aimed to address existing vulnerabilities, and marginalization can be driven by ethnicity or non-residency.

Possible Indicators: Household Composition, Age, Health Status, Social Network, Marginalized Minorities.

References: Twigg, 2001; Downing and Patwardhan, 2004; Blaikie *et al.*, 2005; Dwyer *et al.*, 2004; King and MacGregor, 2000; Kuhlicke *et al.*, 2011; Reid *et al.*, 2009; Bolin and Stanford, 1991, Cutter *et al.*, 2003; Holand *et al.*, 2011; Oudin Aström *et al.*, 2011; Rocklöv *et al.*, 2011, Cutter *et al.*, 2008.

3.5.3 Culture and the perception and knowledge of risk

The focus on local cultural heritage and tradition offers relevant hints on how certain categories might suffer relatively more impact from a hazard because of belonging to, or sharing, a particular identity.

Differences in *ethnicity* might impose language and cultural barriers, and could "effect access to post-disaster funding and could refer to residential locations in high hazard areas" (Cutter, 2003:246). The *educational level* can strongly influence the capacity of individuals to understand warning information and access to recovery information, as well as the ability to adjust in the long run.

Also, *gender* might be a fundamental factor in some contexts, yet it is important to avoid stereotypes in this sense: it is true that different genders have different skills and needs, but presumptions about these capacities can be counterintuitive (Bara, 2010a, p.18). This might be reflected, for instance, by mens' reluctance to seek medical care or psychological support due to a masculine culture of self-reliance (Handmer, 2012, p .169).

The *perceived risk*, associated with some specific disasters – such as floods – comes to play an important role in terms of the measures that might be adopted to decrease economic losses and trigger positive adaptation. The research effort of Siegrist and Gutsher (2006, p. 976) shows that previous flood experience is positively correlated with an adequate risk perception, but also that this fact is not always translated into concrete prevention measures. Also, it appears that prevention behavior is negatively influenced by insurance coverage, and that the feeling of safety generated by an increased efficiency of institutional response leads to an underestimation of the effective risk (De Marchi, 2012, p. 331). According to Steinführer and Kuhlicke (2007, p. 119) the perception of risk resulting from previous experience might even work in the opposite direction and increase peoples' vulnerability to disasters. In the case of the German 2002 flood ofr example, the community coping capacity was felt to be insufficient despite the high degree of awareness due to the occurrence of several floods in the preceding years. Previous floods were seen as a "worst case scenarios" and, in 2002, the horizon of expectation and the space of experience was consequently exceeded for most people, leading to the so called "surprise effect".

Risk *awareness* has also been demonstrated to influence people's responses to a range of natural hazards (see for example, Paton *et al*., 2008). Possible proxies for awareness of a potential hazard include experiences of a hazard, and the length of residence in a hazard exposed location.

Possible Indicators: Ethnicity/nationality, Education, Gender, Awareness; Risk Perception;

References: Cutter *et al.*, 2003, Twigg, 2001; Downing and Patwardhan, 2004; Blaikie *et al.*, 2005; Kuhlicke *et al.*, 2011, Siegrist and Gutsher, 2006;

3.6 Interaction effects between economic, socio-demographic and cultural factors

The previous section illustrates the variety of possible indicators that can, and have been, used to describe social vulnerability in the international context. Indeed, when describing factors that influence social vulnerability (*e.g.* disadvantage, risk perception, economic condition, *etc.)*, several variables are typically

available to use – this reflects the complexity of these social characteristics. However, to date, these complementary social vulnerability-indicating variables have not been associated in existing assessments of social vulnerability and potential interdependencies might be overlooked.

Studies like that conducted by Bara (2010), in Switzerland, illustrate the importance of considering interaction effects between social variables. In doing so, Bara argues that a more specific, rich, and meaningful assessment of social vulnerability can be made. Considering these variables as interdependent, and assessing vulnerability based on this interdependence, can yield results that are more sensitive to the inherent complexity of social characteristics.

In the current study, the research team follows this advice, combining social variables into social vulnerability categories that are meaningful to the context under examination. These categories, and the reasoning behind their selection are detailed in section 5.3 of the methodology. A discussion of the suitability of this approach is provided in concluding section 7.1.

4 Analyzing Social Vulnerability in Switzerland

Switzerland faces a broad variety of natural and technical hazards. Flooding, storms and epidemics are only the most recent events that have been experienced, but the Swiss Risk Register considers a range of 33 potential social, technical, and natural hazards (FOCP, 2015).

Traditionally, the country's civil protection system has focused on mitigating hazards, exposure and structural vulnerability, employing refined analysis, planning and engineering techniques. On top of that, Switzerland's strong federally organized civil protection system encompasses large capabilities to respond to all kinds of disasters. These capabilities reflect Switzerland's highly developed civil protection system, and the highly developed nature of the society. These development features present a valuable opportunity, not just to understant the nature of social vulnerability in developed societies, but also to advance the means of addressing social vulnerability in an integrated disaster management context. The advance quality of the Swiss civil protection system provides an excellent test bed for vulnerability reducing measures, actions that may be considerably more difficult in under-developed or developing contexts, where governance structures and processes are less advanced.

On the other hand, as discussed already in the introduction, the potential for social vulnerability has rarely been analyzed in a systematic manner. A first attempt in this sense is provided by the research effort of Bara (2010) with respect to the Swiss flooding event of 2005. Bara's work is considered, and used as, a precursor that strongly informs the work undertaken in this current project. Bara argues that despite the Swiss society as a whole proving to be extremely resilient in the event, and that most individuals were able of coping with the financial losses incurred thanks to the help of an effective social safety net, some hundreds of individuals were nevertheless excluded from the system, otherwise relying on charitable assistance. Her analysis points out that financial weakness itself is not always a sufficient explanatory variable, but it was rather a combination of vulnerabilities that led to unmet disaster needs, despite the existence of an effective social safety net. Bara underlines the need for a social vulnerability assessment that goes beyond the exclusive evaluation of socio-economic variables, and stresses the necessity to explore the relationships between the community and its part. In conclusion, Bara's findings show that the people most in need of assistance in Switzerland were those already excluded from the social safety net, in other words, suffering *pre-existing inequalities* that were independent of hazardous events. In the future, many of the existing vulnerabilities may be emphasized, due to the effects that environmental, technical and social dynamics might have on Switzerland, such as climate change, urbanization, digitalization and migration (Roth *et al.,* 2014).

This section aims to discuss how to identify potential socially vulnerable groups in Switzerland, based on an analysis of economic, socio-demographic and cultural characteristics of the Swiss population. Particular focus is placed on current trends in Swiss society that may accentuate existing, or create new vulnerabilities.

4.1 Economic aspects of vulnerability in Switzerland

Switzerland is currently one of the countries with the highest living standard in Europe. Since 2007, it has witnessed a general decline in income poverty, a rise in disposable income, and a stable market and economic situation. Despite the overall high level of well being, there is a consistent number of individuals identified as potentially vulnerable in terms of their socio-economic status. In other words, significant social inequalities, leading to exclusion from the social system, are found and are, thus, likely to be exacerbated by unforeseen and extraordinary events.

Some 530'000 individuals were assessed to be living below the absolute poverty threshold[3] in 2014, meaning 6.6% of the total population. If a relative poverty threshold[4] is considered – meaning a monthly income considerably below the standard level of the country – the number of individuals considered at risk of poverty rises to 1.085 million (13.5% of the population). This group is then extremely sensitive to small changes in their situation and particularly at risk of slipping into poverty. Also, the lack of sufficient financial means led in 370'000 cases to material deprivation[5] (FSO, 2014). The main characteristic of the income poor population can be summarized as follows:

- No post-compulsory education
- Single-parent families and people living alone
- Unemployment

Concurrently, the households at risk of poverty possess the following characteristics:

- Have three or more children
- Do not hold a Swiss passport

[3] Absolute poverty threshold: 2200 CHF per individual, 4000 CHF for two adults with two children

[4] Relative poverty threshold: 2500 CHF per individual, 5200 CHF for two adults with two children

[5] People unable to afford at least three items from the following list: ability to face unexpected expenses of 2500 CHF, ability to afford a week of holiday every year, no arrears, ability to afford a meal with meat, fish or vegetarian equivalent every second day, ability to keep the home adequately warm, having access to a washing machine, owning a TV, a telephone and a car.

- Are not employed constantly during the year or are part-time workers

Similarly, Bara (2010:249) identified in the 2005 flood case study the vulnerabilities arising from precarious working and living condition as key to understanding the social groups unable to cope with the disaster consequences by their own means. Precarious conditions refer to non-standard employment (poor salaries, unsecure and unprotected jobs) and the overall inadequacy of financial resources, enhanced by the lack of social connections, which might be otherwise relied on to provide material and affective resources in times of need. In other words, the socially isolated (such as independent artists, old people in peripheral regions, foreigners with low income) whose vulnerabilities differ greatly and cannot be neatly categorized, who are living at the margins of the society and are "only an illness, broken down car, or temporary job loss away from personal disaster."

Particular attention is given to the danger of considering vulnerable those individuals below an absolute poverty threshold in terms of their annual income, especially in the case of a disaster. Bara underlines the vulnerability of the middle class, and reports that also that portion of population who is able to manage with an adequate life condition (for instance, owning property and not being considered poor or financially weak – earning more than 80.000 CHF per year) was not necessarily able to cope with the financial losses suffered in the flood event. This highlights that a lack of sufficient savings to cope with the unforeseeable and uninsurable circumstances can also influence the vulnerability of middle class citizens.

This analysis leads to two major conclusions: firstly, the need to observe a combination of factors rather than single measures that captures potential interaction effects (see section 3.6); and secondly, to consider vulnerability in relative terms without prejudice or an over-reliance on income-related indicators. As Bara reminds us, "everyone, except maybe the very rich, is potentially vulnerable to severe financial losses". The following paragraphs explore in more detail two dimensions related to socio-economic deprivation, namely: the household structure and the foreign population.

4.2 Vulnerable socio-demographic groups

The structure of the household seems to be a key element to understand peoples' vulnerability to hazards and their difficulties to adjust in the lon-term. It emerge from the data that some population groups, commonly identified as vulnerable to poverty in the literature, are not necessarily worse-off because of their belonging to a certain category. Rather than the condition itself, it is the individual or household complete situation that leads to an increased exposure. Two important goups are women and the elderly. In the Swiss context, women seem to be more vulnerable due to the frequency they take responsibility for their children in daily life and in cases of divorce, increasing the likelihood that they beecome lone parents (FSO, 2014; Bara, 2010b, p. 250). This vulnerability is increased in the case of unemployment or under-employment conditions (FSO, 2014). Additionally, being an immigrant woman from a less developed country might boost the risk of being discriminated and devaluated, and these members of society often suffer a higher degree of emotional distress and self-confidence loss (Riano and Baghdadi, 2007:165). Last, the lack of education might add further sensitivity and reduce personal capabilities to seek help or connect with social networks (Pecoraro *et al.*, 2014). According to the FSO, the aged population showed a higher poverty rate because the measure of income poverty does not consider other financial assets: people aged 65 and over usually rely on savings for their daily expenses. There seems to be an increase in their vulnerability not strictly related to age, but rather to the fact that they often live alone (FSO, 2014).

From a demographic perspective, past research on the Swiss population highlights the importance of considering family composition in the context of social vulnerability. This underlines the higher social exclusion and sensitivity to risks of individuals living alone, and single-parents that need to take care of dependent family. This is true also in the opposite direction, meaning large families with three or more children (FSO, 2014).

4.3 Culture and vulnerability in Switzerland

Switzerland is a multicultural nation with geographically disparate national languages. Existing research highlights that migrants (legal and illegal) are relatively more 'at risk' from natural hazards (Donner and Rodríguez, 2008). Migrants may not be familiar with local environments, or languages, or may be culturally non-responsive to risk warnings or information. As such, locating and supporting migrant populations must be an meriting consideration in the context of disaster management.

In Switzerland, 25% of the total population are foreigners, the majority of them coming from EU states. Italians comprise the largest group (15.3%), Germans 2nd (14.9%), and Portugese 3rd (13.1%). A realtively large, and growing proportion (likely to expand with respect to Europe's recent migrant influx) of migrants originate from Eastern Europe (9%).

Furthermore, according to a recent study undertaken by the Swiss State Secretariat for Migrants (SEM, 2016), it is estimated that about 76'000 illegal immigrants – *sans papier* – are living in the country. The majority of these originate from Latin America (43%), non-EU European States (24%), Africa (19%), and Asia (11%).

With regard to the foreign population, it is important to note the role of socio-economic factors first, and nationality secondarily. The higher vulnerability of

immigrants – especially if coming from a southern state, or asylum seekers often without a residence permit – is given by a combination of low educational level and economic inactivity, affecting the personal network and compromising individuals' health and psychological status. This factors contribute to peoples' vulnerability regardless of their belonging to a foreign country or to Switzerland (Pecoraro *et al.*, 2014, p. 10).

The gender dimension within the immigrant population also requires special attention. Past research highlights the fact that immigrant women are less considered to be participating in the labor market in comparison to immigrant men, and are often affected by a deskilling process (Kofman, 2000). Women are frequently entering Switzerland with family-class visas rather than a working permit, and existing gendered structural barriers – for instance, child-raising responsibilities, gender discrimination by employers and ethnic prejudice – seem to set constraints on their access to skilled jobs, regardless of their academic and professional qualifications (Riano and Baghdadi, 2007, p. 165). Some immigrant women appear to be in a particularly vulnerable position because of a combination of factors that are directly affecting their emotional stability and personal networks, namely: low education, unemployment, low income, lack of local language skills and short-term residence permit. Women who are working, in fact, report lower rates of mental distress with respect to those staying home (Pecoraro *et al.*, 2014, p. 2). The agency of immigrant women, in other words the feeling of control over one's life, is significantly improved by active participation in the labor market (Riano and Baghdadi, 2007, p. 167).

In this sense, a growing body of literature illustrates a hypothesis concerning the so called "healthy migrant effect," which switches an assessment of vulnerability to the length of stay of foreign population. According to this theory, recently arrived immigrants seem to be healthier than the native population at the time of their arrival, but once settled in the hosting country this effect deteriorates and a significant gap with the health status of locals is witnessed. This is especially true for women and for immigrants coming from developing countries (Malmusi *et al.*, 2010, p. 12; Pecoraro *et al.*, 2014, p. 2).

4.4 Choice of Social Vulnerability Indicators

In the light of this context analysis, some major social vulnerbaility indicator groups suitable for Switzerland include:

- Income
- Age
- Disability
- Savings
- Employment
- Household structure
- Nationality and Visa status

4.4.1 Income

Income level is an indicator that requires careful handling, as the setting of both absolute and relative poverty lines might, in some cases, mislead a judgement on the relative importance of the indicator in relation to vulnerability. For this reason, it may be more important to consider income in the context of another characteristic, like household savings or household type. As Bara (2010) noted, past experiences have shown that consistent financial losses can impede recovery (also for population groups not considered as poor), if sufficient savings to cope with unexpected expenses are absent. By contrast, people with no direct income sources, the elderly for instance, but with considerable savings, might instead be able to afford unforeseen expenses.

4.4.2 Age

As in most western cultures, Switzerland is characterized by an aging population. Again, while age is not necessarily a predictor of vulnerability by itself: for instance, older people living in a home for the elderly may not be at risk because of mitigative actions taken by the organization running the home. However, an elderly person, living alone may be vulnerable because they have no one else who can provide support.

4.4.3 Employment

The employment condition is not exclusively an adequate indicator of one's economic status and stability, but works also as a proxy for other dimension if combined with the other indicators and, mostly, if observed over time. Prolonged economic inactivity of population in working age can be a sign of one's inability to cope with new – and, in the case of a disaster, extreme – demands. Also, job insecurity yields to an extended condition of uncertainty both in economic and psychological terms.

4.4.4 Household type

The household composition completes the picture. It provides information on how the resources identified with the previous indicators have to be divided. Therefore, the difficulties encountered by lone parents or large families with several dependent members can be observed. Also, single-person households are distinguished for higher susceptibility, may it be in terms of social, material or economic support.

4.4.5 Ethnicity and nationality

The argument regarding ethnicity as possible indicator is more critical. While the above mentioned indicators are sufficient to identify potential vulnerabilities that affect all nationality equally, the do not account for the potentially higher degree of social isolation of immigrants and for the greater difficulties they might encounter, especially when coming from low income countries and staying without a visa permit.

4.4.6 Experience and hazard awareness

Individuals' experiences and awareness of risks from natural hazards

4.5 Social Vulnerability Mapping in Switzerland: wider use beyond hazard management

Aside from the benefits understanding and mapping social vulnerability presents in the context of civil protection, this analysis is also useful to understand the development of other social patterns in Switzerland. Three broad social developments in particular can be better understood and followed using a similar methodology applied in this study: mobility, immigration, and aging. The trends associated with these social features are likely to strongly influence many aspects of policy in the future. As such, understanding the nature and extent, on one hand, of the population segments driving these patterns, and on the other, the population segments likely to be effected by these societal developments can be very useful for prospective policy development. The utility of social vulnerability assessment and mapping with respect to these social characteristics are briefly explored here.

4.5.1 Mobility

Recent research by the Federal Statistical Office suggests Swiss are travelling further on a daily basis, mostly for work (FSO, 2016). In 2014, 10% of all commuters were travelling at least between cantons. Given the nature of the Swiss urban system, and the ever-improving transportation (road and rail, predominantly) systems, an increasing trend is predicted here (Viry and Vincent-Geslin, 2015).

Using a similar methodology as the one developed in the current study, social characteristics that could potentially influence patterns of mobility, both for work and pleasure, could be mapped in support of transport planning. For instance, knowing how changes in residence patterns of long-distance commuters over time could be used to plan the frequency of inter-city trains in Switzerland. By combining this information with, for instance, data on average income and income development, could also inform pricing of the Swiss travel card with respect to commuter purchasing power.

4.5.2 Immigration

The European migration 'crisis' has seriously tested Europe's civil protection organizations in the last several years. Recent work facilitated by the CSS Risk and Resilience team suggests that, at least in the German speaking part of central Europe, challenges associated with this human movement will continue or even grow into the near future.

Managing this mass movement of people has proven difficult, not least because of the sheer numbers of people moving, but also the number of organizations involved in managing the movement and resettlement of migrants. Understanding and mapping the social vulnerability characteristics of those people on the move, on small scales, and regularly, could provide a valuable picture of groups that could help inform management priorities and practices, if coordinated between destination and transit countries. For example, real-time mapping of the health, age, language characteristics, and other special needs along different migration routes can allow authorities to communicate issue and characteristics 'downstream', increasing the suitability of planning and relocation activities.

4.5.3 Aging population

In 2012, for every hundred people in Swiss cities, between 25 and 35 of these were older than 64 years (BFS, 2016a). The Swiss population is aging, and in the next 10 years, the peak of the Swiss age pyramid will broaden further (BFS, 2016b). Understanding the relationship between social factors that influence the age structure of Switzerland, including birth and death rates, immigration, life expectancy, *etc*., can be informative in planning measure to mitigate the impacts of aging within the society.

5 Methodology

The following section outlines the key methodological considerations and steps followed in the study. Specifically, we discuss the choice of Zürich as the location of the study and why we focus on flood hazard. Further, the operationalization of social vulnerability in the Swiss context is described. Finally, the main data sources used in the pilot study are discussed.

5.1 Study Location Choice

The City of Zürich was chosen as the study location for two reasons. First, the city, and Canton are leaders in mapping risk in Switzerland, with a strong interest in broadening their practices to increase the sensitivity of their maps to all aspects that increase risk in the city.

Flood risk mapping is not a new practice in the Canton and City of Zürich. Indeed, the Canton of Zürich has recently engaged consultants (Egli Engineering AG) in a detailed flood risk mapping process that has resulted in the map illustrated in Figure 2[6]. This risk mapping exercise has brought together an analysis of a broad variety of risk classes in the context of flood risk in the Canton: risk of supply (hospitals, transport, power/communications networks, *etc.*), social risk (points of social intensity like universities, shopping centres, *etc.*), cultural risk, environmental risk, material risk (building value, *etc.*) (Rüttiman *et al.*, 2014).

While structural social vulnerability elements are considered in the modeling process, non-structural social vulnerability (the focus of this current report) has not been included in the mapping process. The opportunity to incorporate the results from the current social vulnerability mapping project, into the Canton of Zürich's existing flood risk map is a valuable contribution to the risk mapping activity already established. This study takes the opportunity to characterize and map social vulnerability in Zürich.

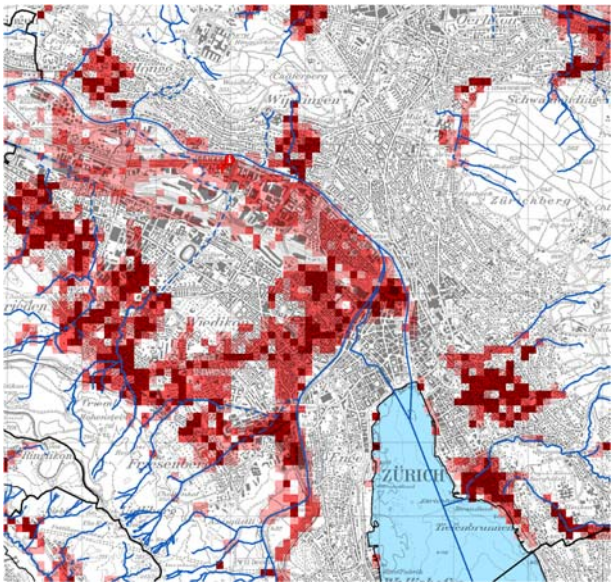

Figure 2: Canton of Zürich Flood Risk Map. Amt für Abfall, Wasser, Energie und Luft.

Second, Zürich is a wealthy city, with a well-established civil protection tradition. At the same time the city is a very dynamic environment, where social mobility, urbanization, immigration, and socio-demographic changes are influencing both the character of the city, and the complexity of managing hazards (see section 4.5). For these reasons, the city represents a good case to study social vulnerability in affluent contexts, where affluence is interdependent with these broader social dynamics. Additionally, the project team has an experience working with civil protection personnel both at the city and cantonal levels, simplifying the collaboration.

The focus on Zürich is narrow geographically, but as this study was a pilot and sought to demonstrate a technique, the narrow focus was necessary.

5.2 Choice of Hazard

Flooding is one of the main hazards facing the city of Zürich. Especially the centre of the city (and train station) is a high-risk area, not because of the threat level, but because of the exposed assets located close to the confluence of the Sihl and Limmat Rivers.

Due to the high level of risk flooding poses in the city, extensive risk mapping has been conducted (actually across the whole Canton of Zürich). This has increased the familiarity of civil protection personnel to the potential of mapping capacities for informing risk management actions.

5.3 Social vulnerability characteristics and their disaster mitigation-relevant proxies

As we have already discussed in section 2.4, disaster risk management is typically organized as a cyclic process. Also the Swiss system follows this basic outline (BABS 2015, Figure 3). In order to demonstrate the broad value of a social vulnerability perspective to disaster risk management, the research team aimed to identify social vulnerability characteristics relevant to typical issues at each of the three phases in the Swiss model of disaster risk management: Preparedness; Response; Recovery. Relevance in this context is established based on an academic understanding of social factors that are typically central elements in disaster mitigation practices.

Three disaster mitigation elements were the focus of this effort: evacuation, risk awareness, and hazard coping capacity (in relation to household-level mitigation

[6] Amt für Abfall, Wasser, Energie und Luft. http://www.awel.zh.ch/internet/baudirektion/awel/de/home.html

actions). Two or three associated social characteristics (termed categories) are used as proxies for each disaster

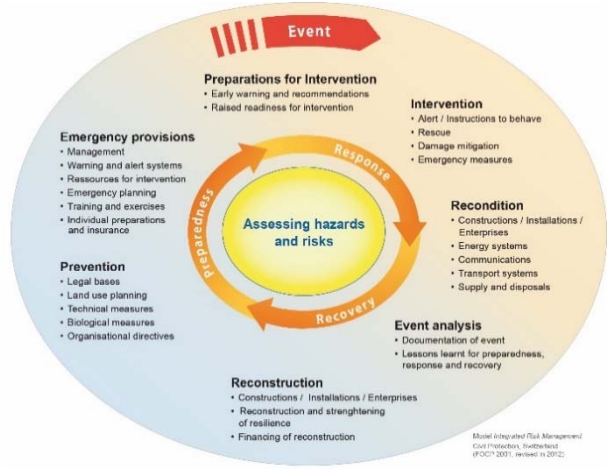

Figure 3: Swiss Integrated Risk Management Cycle. From FOCP, 2012.

mitigation element, described here. These categories are not intended to represent a definitive social vulnerability explanation of each disaster management element, which could be articulated with a range of (contextually specific) characteristics, but represent a sensible characterization for the current pilot project.

5.3.1 Response phase: Evacuation

The ability to effectively evacuate at-risk residents is a fundamental element of the Swiss civil protection system. Many factors influence the ability of emergency managers to evacuate people, including disability, difficult access or mobility problems, language barriers, needing special assistance, or contradictory perceptions of risk. The research team identified two factors likely to exaggerate social vulnerability in the context of flooding: old age, and living alone. Older people are often less mobile, and require mobility assistance, or help to interpret risk and evacuation messages in their own contexts. Examined together, both factors can exaggerate social vulnerability. To put this relationship between factors into context, older people living in extended families, or in homes for the elderly, may be less mobile, or require message interpretation assistance, but the household environment in which they live is likely to be able to meet these requirements. As such, the social vulnerability category used in this study as a proxy for ease of evacuation is elderly women (older than 80 years) living alone.

5.3.2 Preparation phase: Risk Awareness

Research examining the social cognitive precursors for natural hazard preparedness behavior and action highlights that an awareness of risk is fundamental in this process (for example, Paton *et al.*., 2008). For many members of the public risk awareness provides a fundamental cue in taking action to minimize the consequences of hazard: this is often, but not always the case, and socio-cognitive research on hazard preparedness decision making suggests that the relationship between risk awareness and action is itself mediated by other factors (*e.g.* preparedness outcome expectancy, self-efficacy, inhibitors like time, money and knowledge, *etc.*). Despite this complicated relationship, risk awareness still plays an important role in the way people pay attention to risk information, preparation or evacuation messages. A proxy for risk awareness used in this study is the length of residence of a person in a potentially risk affected location. In this study, length of residence is captured by data on the number of households in a statistical zone that are recently enrolled on the City of Zürich's population register. Non-Swiss new arrivals (those without long-term residence permits – so excluding EU citizens), potentially lacking competence in German, are considered more vulnerable again, because a language deficiency inhibits these people or households from engaging with German documentation on hazards and their household-level management. Thus, the second social vulnerability category used in the study are households newly arrived in the City of Zürich and lacking a long-term residence permit. This group might include students, international professionals (working in the finance sector, for instance), and diplomatic personnel.

5.3.3 Recovery phase: Coping Capacity

Natural hazard introduce non-standard challenges to householders everyday lives. For example, dealing with the potential of a risk by preparing one's household and property requires people to acknowledge the risk and its possible consequences. Coping capacity is the ability of an individual or household to manage the risk in their situation – whether investing time or money to prepare for a risk so that they might mitigate the consequences of that risk. Time and money are two of the most significant factors limiting coping capacity in the context of natural hazards. Time and money can be limited in single parent households, and this category of household was the focus of the final social vulnerability category in this study. Data describing single mother households with a monthly income in the bottom 25th percentile of households is used.

5.4 Data Sources

In undertaking a conceptual analysis of social vulnerability in Switzerland, several sources of social characteristics and hazard information have been identified. Sources of social information are described below. Given the limited scope of this pilot study of social vulnerability (focused on flooding in Zürich), social data for this project were sourced solely from the City of Zürich Administration. Hazard mapping information was provided by TK Consult, a hydrological modelling firm working with the Canton of Zürich to model ground- and surface-water flows in a flooding event. For a geographically broader analysis of social vulnerability across Switzerland, data must be drawn from all sources listed below.

The City of Zürich collects and integrates a broad variety of data from individuals and households that is

relevant in the assessment and mapping of social vulnerability in the city. Data from the city census (Neue Strukturdatenhebung) is connected to the citizen register (which records information from families moving into the city). Both sets of data are connected to the city building registry (geographically localizing the census and citizen registry data). In addition, this same organization of data is available for the whole of Switzerland (though not always at statistical zone level), being collected by community administrations nationally. Other useful social vulnerability data collected by the city, but dissociated from the above data sets, is the city's citizen survey, which collects a range of individual and household level information (for example, the frequency German is spoken in the household). Additionally, information on asylum seekers and hazards is collected and managed by the cantons in Switzerland.

In the current pilot study, data were obtained directly from the City of Zürich. These data were aggregated by the City of Zürich Statistics Office to match social vulnerability characteristic categories identified by the research team, and described in section 5.3. Data are based on 2014 Tax data.

Although data is available from the City of Zürich to the individual level, household level data is used in this study for two reasons. First, by simply using a count of the number of households meeting the social vulnerability categories examined, the privacy of individuals is maintained. Where 'hotspots' of social vulnerability are mapped using this process, risk managers (either city or canton) can still examine the source of the data to target risk mitigation actions more specifically, if they wish.

Second, for the purposes of this pilot study, collecting data from individuals was considered to be an unnecessary detail. Again, if government risk management agencies see value in understanding and mapping individual social vulnerability, the data to conduct such an assessment exists in Switzerland, permitting a finer examination.

In consultation with the City of Zurich and the Canton of Zurich, flood model data were provided by the consulting firm TK Consult AG. These data were provided to the research team in the form of a Geographic Information System (GIS) shapefile.

5.5 Data Analysis and Mapping

The detailed shapefile included information both on extent of flooding (in a 300 year event), and on the depth of the modeled flood. Such a level of detail was unnecessary for the current pilot study, and was accordingly simplified to display areal extent of the flood.

This shapefile was introduced as a separate layer into the GIS program Arc Map and converted to a feature layer that could be overlaid onto the city household data.

Through the City of Zurich's Open Data website[7], the research team obtained a GIS 'feature service' which could be used to arrange the statistical zone household information. All mapping of household data was undertaken directly in the Arc GIS for Office, Excel AddIn program.

Lastly, hotspot analyses were conducted for each of the three social vulnerability categories. The hotspot analysis is a calculation of the spatial clustering of the mapped features relative to the features mapped close by: in this case households meeting the specific social vulnerability categories. The analysis returns a z-score (standard deviations), where higher scores reflect greater clustering of features (H_0=feature randomness). The returned hotspot analysis illustrates areas of high clustering (several standard deviations above the mean), and points on the map of no clustering (several standard deviations below the mean). Figure 4 depicts this distribution, showing the relationship between the z-score and the p-value.

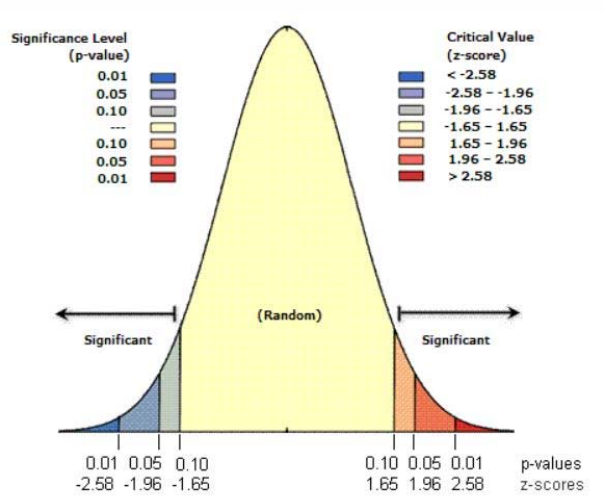

Figure 4: Z-scores and p-scores associated with a normal distribution. Arc GIS Online, from arcgis.com.

[7] https://data.stadt-zuerich.ch/

6 Mapping Social Vulnerability to Flood in Zürich

This section outlines the main results of the GIS-based mapping of social vulnerability categories. All reported information is based on the number of households in each statistical zone meeting the social vulnerability category characteristics. Household densities are overlaid with the mapped extent of area affected by a 300 year flood event. This has to be considered to be an extreme, though still possible scenario. For each social vulnerability category, a hotspot analysis also highlights key areas of statistically significant household density.

In this pilot, there were few areas of the city where pockets of social vulnerability actually overlapped with areas of high flood hazard and social exposure in Zürich. However, the mapping does illustrate some areas in the city where 'hotspots' of social vulnerability exist. These areas are presented in section 6.3, accompanied by a brief description of the social vulnerability patterns. Overall, the mapping process is illustrative of an informative and practical method of identifying areas of social vulnerability.

6.1 Flood Hazard in Zürich

The Canton of Zürich has engaged the hydrological modeling consultant TK Consult AG to model both surface and groundwater flooding in the City of Zürich. This work has been undertaken at a very fine scale down to the hectare level. In addition, based on projected flood intensities, the firm has modeled and mapped various flood intensities: a 100 year flooding event, and a more significant 300 year flooding event.

Figure 6: Projected 300 year flooding extent. Data supplied by TK Consult AG.

[8] The research team is awaiting data on the building level in which each household is located, but at the time of drafting, this information remained unavailable.

Given the extent of projected flooding is higher in the 300 year flood model, mapping for this extent is used in the current study (Figure 6). Given the significant flood protection measures in the city of Zürich, the extents of the 100 and 300 year floods differ only minimally.

6.2 Social Exposure

Figure 6 shows both flooding potential along the rivers Sihl and Limmat, and particularly in the low-lying areas of the centre of the city. Here there is a large resident population (Figure 5), though the housing stock is typically multi-level, and the number of people living on the ground floor, or basement levels is relatively low.[8] It is interesting to note that as the Limmat continues further from the city, the extent of flooding potential along the banks broadens beyond the city limits (in Schlieren and Dietikon in particular).

6.3 Social Vulnerability to Flooding

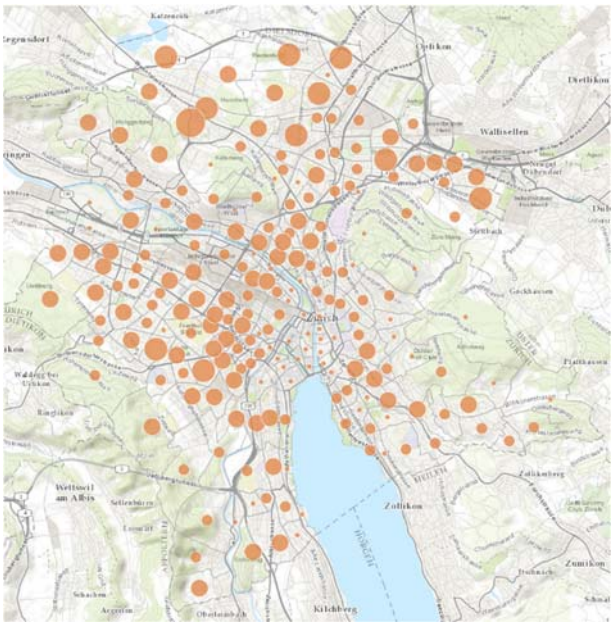

Figure 5: Population density in the City of Zürich. Data aggregated at statistical zones. Data supplied by the City of Zürich.

This section describes the geographical location of hotspots of vulnerability. It is important to precede this presentation of results with an acknowledgement that the study does not aim to explain the root causes of social vulnerability. Understanding these preconditions can help in the search for solutions to social vulnerability, but this is a complex endeavor and simply beyond the scope of this report, though the mapping results can certainly be used to direct efforts toward understanding these social issues.

From a civil protection perspective, the existence and location of hotspots of social vulnerability, and the nature of that vulnerability, are the primary concern.

With this information, the civil protection authority has information that can inform activities like the development of risk messages, evacuation planning, advice on preparedness, and support for members of the population that require it.

Importantly, only the three social vulnerability categories already presented as pilot categories are reported here. These results do point to further avenues to increase the specificity of these social vulnerability categories (for instance, by adding further social characteristics to the categories). Such extensions are presented in section 7.1, when discussing the advantages and limitations of the interdependence approach to social vulnerability as applied in this study.

6.3.1 Elderly women living alone in Zürich

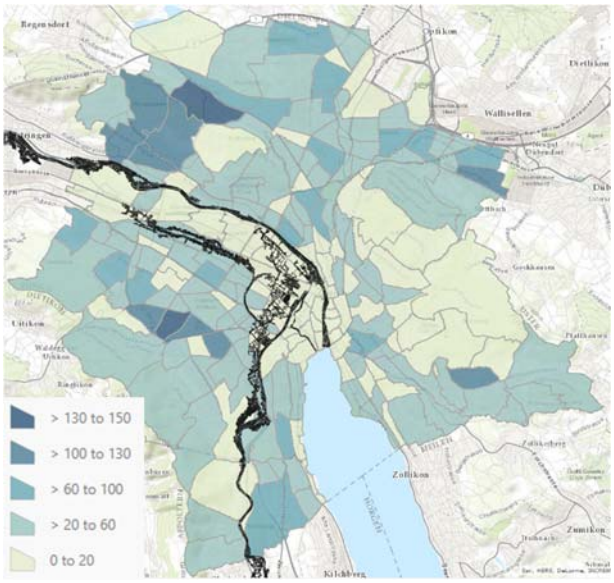

Figure 7: Density (number of households) of elderly women living alone in Zürich. Data supplied by the City of Zürich.

This social vulnerability category was chosen as a proxy to map households that might be difficult to evacuate in the event of a flood. Figure 7 shows the distribution of elderly women living alone in Zürich. With darker areas on the map signifying more households that satisfy this category, it can be seen that, broadly, the northern and western quarters of the city have the greatest number of elderly ladies living alone. This observation is supported by the 'hotspot' analysis of this data (Figure 8). In both cases, these areas are quite distant from the mapped flood risk area (represented here in black). This would suggest that this vulnerably social category is reasonably safe from flood risk in the context of the Limmat River.

However, along the Sihl River, to the south of the city, in the Leimbach and Adliswil areas, there are higher numbers of elderly women living alone. These areas could be targeted by civil protection authorities seeking to plan evacuation processes in these areas, not just in the context of flooding, but from an all-hazards perspective.

6.3.2 New foreign residents in Zürich

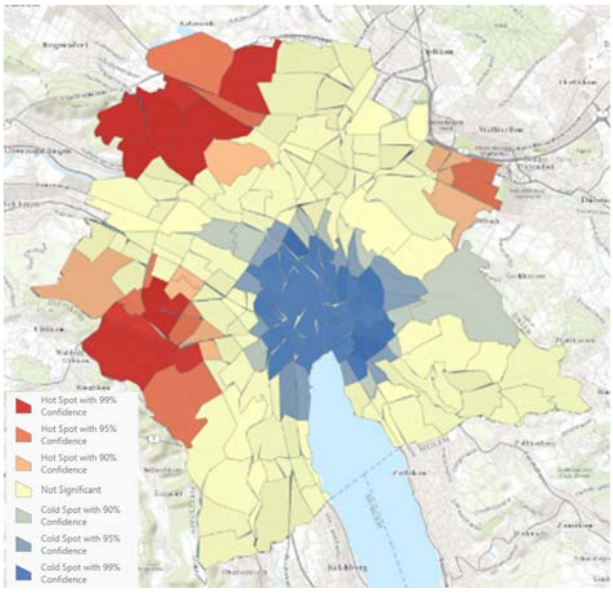

Figure 8: Hotspot analysis of elderly women living alone in Zürich.

This social vulnerability category was chosen as a proxy for awareness of local hazards, and the extent to which households understand risk and household-level risk management actions (Figure 9).

This category overlooks economic wealth of the household, because this characteristic has been demonstrated to be independent of experience gained from previous hazard events, which can increase risk awareness. This category focuses on the relationship between a household's familiarity with the area (including the hazard environment) in which they live,

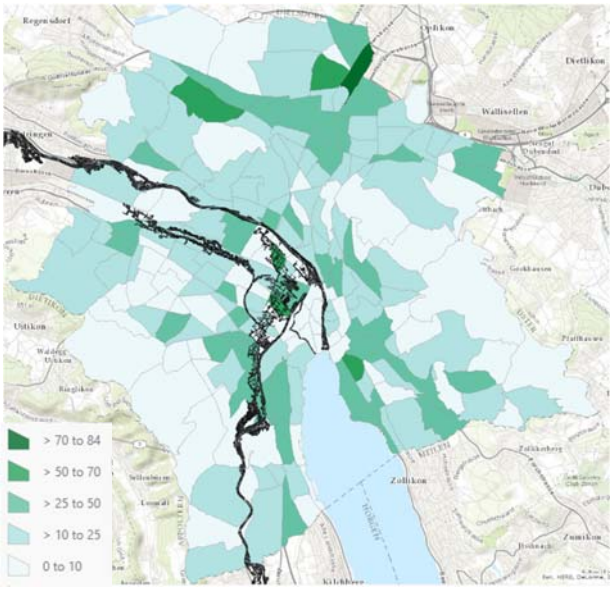

Figure 9: Density (number of households) of newly arrived foreigners without a long-term residence permit in Zürich. Data supplied by the City of Zürich.

and their knowledge of emergency processes, services, alerting, and recovery support. It captures the number of households in each statistical zones of the city that are

both newly arrived (based on the city's residence register) non-Swiss without a long-term residence permit. Because it does not focus on economic factors, this category captures very different foreign resident populations of interest in the context of flood risk awareness.

This map illustrates two broad areas where new foreign residents are living. The first is a loose grouping in and close to the centre of the city, and along the edge of the Lake of Zürich. The second is located in the fast developing area in Seebach and in Oerlikon. However, an analysis of hotspots for this social vulnerability category did not support this observation, with no significant concentration of newly arrived foreigners in the city (Figure 11).

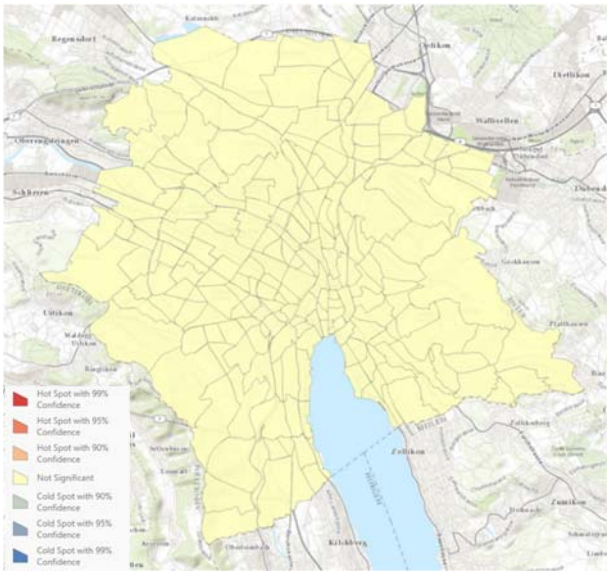

Figure 11: Hotspot analysis of newly arrived foreigners without a long-term residence permit in Zürich.

Certainly, those households located in the centre of the city, along the Sihl, are in areas of projected flooding during an extreme event. However, again, the actual number of households at risk in this area is likely to be low because of the type of housing stock, and relatively few people living in the lower floors of multi-level buildings. Foreign resident households along the Lake of Zürich shoreline (particularly in the Riesbach, Bellerive, and Tiefbrunnen areas) are likely to be at risk of flooding during a 300 year event (though this area's flood extent has not been modelled and is not mapped here), and prospectively this area should be of interest to civil protection organizations in terms of increasing local residents' awareness of flood risk, and risk mitigation measures. Residents in the north-western part of the city falling into this social vulnerability are not at risk in the event of a 300 year flood, based on the flood projections mapped here.

6.3.3 Single mothers with a low income

The third social vulnerability category examined in this pilot study were households characterized by single mothers with a low income (in the 25% quantile, *i.e.*, less than 27'785 CHF/pa). Both time and ready finances influence the ability to prepare for and respond to hazard events, and this category seeks to capture

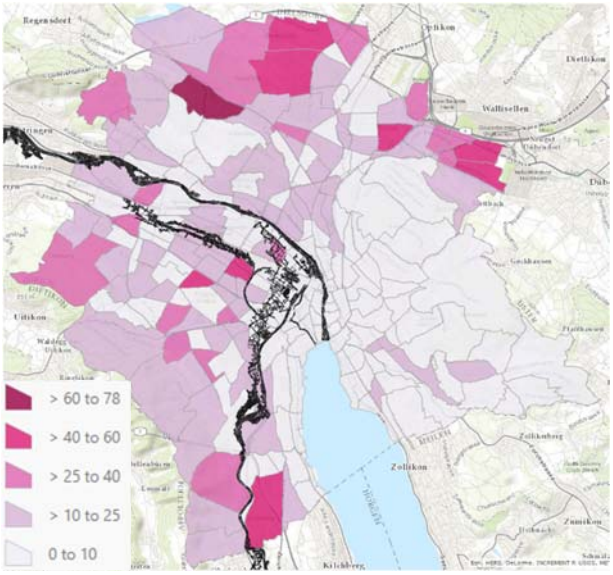

Figure 12: Density (number of households) of single mothers with low income in Zürich. Data supplied by the City of Zürich.

households where both time to prepare, and finances to support preparation and response are limited (Figure 12).

In this case there appears a concentration of low-income single mothers in the northern part of the city, a

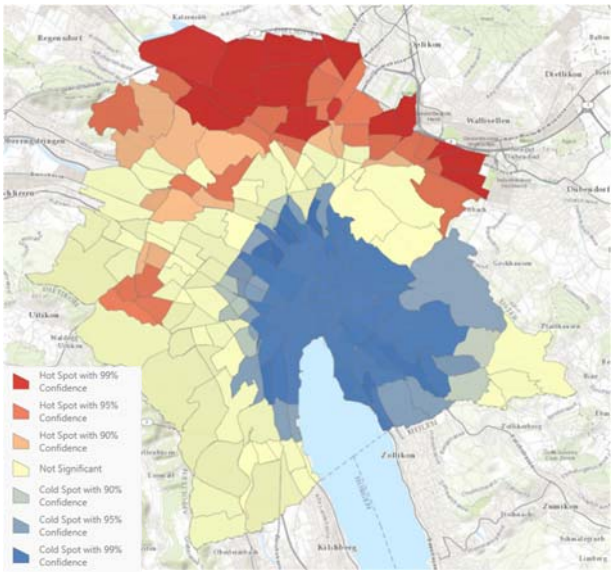

Figure 10: Hotspot analysis of single mothers with low income.

pattern supported by the hotspot analysis of this social vulnerability category (Figure 10). This area is well away from flood risk areas mapped here. However, individual statistical zones, particularly along the Sihl (Figure 12), appear to have denser concentrations of low-income single mothers – in Wollishofen (Entlisberg), and in the Hard/Guterbahnhof area of the city. However, these densities do not appear significant based on the hotspot analysis conducted here.

7 Conclusions and Implications

Overall, this pilot study has demonstrated that mapping social vulnerability is a useful practice to complement existing integrated risk management activities. Three points are particularly important. First, that social vulnerability exists in a wealthy city like Zürich, and it can be characterized interdependently (formulated in this report as a social vulnerability category) from several social factors.

Second, the project has demonstrated that mapping these social vulnerability categories is possible, practical. While the extent of flood risk-affected areas in Zürich is limited, meaning the overlap between pockets of social vulnerability and flood hazards are quite limited, the mapping technique applied here could easily be broadened geographically (including in other urban and rural areas of Switzerland); could be broadened in the context of social vulnerability categories (when a theoretical basis for combining social characteristics can be established, as in the case of the three used here); and could be broadened in the context of a diverse range of hazards (as long as the extent of these hazards has been, or could be, mapped). More importantly in the context of the development of social vulnerability categories, the availability and accessibility of social data is reasonably high in Switzerland.[9]

Lastly, but most importantly from a risk management perspective, this mapped social vulnerability information adds a fundamental facet that can help civil protection officials to locate pockets of social vulnerability in Switzerland. Locating social vulnerability is the first step in reducing vulnerability in a targeted and efficient manner, and our findings can direct civil protection professionals towards zones of vulnerability that may have been overlooked in the past. Addressing social vulnerability also allows civil protection officials to approach total vulnerability (social and structural) in a more comprehensive manner. Reducing vulnerability of people and structures provides a greater return on investment, from a risk-reduction perspective, than reducing exposure or the hazard (which may be impossible). This relationship was explored and tested (in the context of avalanches) in a cost-benefit analysis for risk reduction by the Swiss Platform for Natural Hazards (Bründl, 2009). For this reason, a focus on understanding and locating social vulnerability in Switzerland is likely to further improve Switzerland's overall civil protection system.

These three outcomes of this pilot study are explored in more detail in this section.

7.1 Social Vulnerability as Compound Characteristic

The purpose of this report was to offer a method of first understanding, then mapping social vulnerability in the Swiss context. The concept of social vulnerability, regardless of the diversity of perspectives in the literature, and the lack of an agreed universal definition, encompasses a common concern: the "susceptibility of human beings to harm from events, processes and changes in their physical and social environments" (Handmer, 2012). It is, therefore, a human-centered concept that focuses on individuals' capabilities and interactions, the ways they shape the society structure and how this structure might lead to a disproportional susceptibility of some population groups during all the phases of a hazard occurrence.

As such, social vulnerability is a feature of the population that exists before the occurrence of a hazardous event, which exaggerates the weaknesses of a community with regard to the impact from the hazard. The importance of the inclusion of the social aspects of vulnerability in disaster risk reduction has been extensively acknowledged by the research community, but not yet been formally or systematically incorporated into the practices of emergency preparedness and response professionals across Europe. In fact, these features of the society have historically been overlooked simply because they are mostly hidden, and certainly less obvious, in developed societies, where socially vulnerable people are typically in the minority, and generally considered to be treated sufficiently by advanced state welfare services provision (Bara, 2010b).

Vulnerability can be seen as a "*continuum* of vulnerable situations" within which people fluctuate. It represents a range of conditions that social groups share, but where the distribution of resources to avoid or escape hazards is unequal (Ranci 2010, p. 17; Mathieson, 2008, p. 32 citing Castel, 1998, p. 129). Individuals are put in a condition of "continuative uncertainty", preventing them from protecting their futures in the long-term (Castel 2000, p. 520). In other words, vulnerability seems to arise due to an unequal distribution of social risk among the members of a community (Beck, 1992, p. 199). Rather than merely lack of economic resources, it is the absence of stability that undermines a person's capacity to convert the means at his or her disposal into the capability to cope and recover from adverse events (Ranci 2010, p. 18). For example, the level of one's wealth is not fundamental by itself (a person might have a low income, but extensive savings that help them to cope in the event of a hazard), but because it is an important *means* to reach the *end* of personal well-being. However, taken together with a complementary social characteristic, which might for instance limit the individual from increasing their personal wealth (and therefore the ability to cope with a hazard), like being a single parent, then the social

[9] Data from the City of Zürich was accessible through the city's open data policy. A fee was paid in order to have accessible data arranged in such a manner to allow ease of application in mapping. It must be recognized that data availability and accessibility may be lower in other parts of the country, though the Swiss Federal Statistical Office can likely provide data that may not otherwise be accessible.

vulnerability of the individual is exaggerated. That is, the capability to gain a standard of living sufficient to cope in the event of a hazard, is realized through one's agency (Sen, 1999, p. 5). Herein lies the importance of considering the relationships between social characteristics as the basis for understanding social vulnerability.

Due to the significance of the relationship between social vulnerability and disaster, it is therefore important to develop specific analytical tools that can understand and account for the growing degree of complexity of modern post-industrial societies. Currently, existing literature provides several attempts to measure social vulnerability, and proposes a variety of frameworks and approaches. Their major characteristics, differences and limitations are examined and summarized in section 3 of this report. Although a common framework is lacking, and the choice of indicators differs greatly among the articles that are reviewed in this study, in Switzerland it is clear that social vulnerability can best be characterised by combing socio-demographic, socio-economic and cultural characteristics. More specifically, these characteristics can be combined to reflect important social elements of the integrated risk management process.

7.1.1 Matching Social Vulnerability to the Integrated Risk Management Cycle

The conceptual part of this project demonstrates that social vulnerability must encompass different dimensions of peoples' lives. At the same time, for the purposes for which it is intended in this case – to understand social vulnerability in the context of risk management – it must also have a meaningful application. For this reason, the authors have drawn on the risk management cycle as a means of guiding the selection of socio-demographic and socio-economic characteristics for combination in the social vulnerability categories analysed and mapped in this project.

The three key elements of this cycle chosen, evacuation, risk awareness, and coping capacity, reflect the different stages of the cycle. In part, this demonstrates how addressing social vulnerability can be directly connected to key activities in the risk management cycle. It also highlights the versatility of social data with respect to activities that have either been dealt with very technically in the past, or not addressed at all.

Establishing social vulnerability categories that match the risk management cycle also provides a basis on which to benchmark changes in social vulnerability. This is also important because benchmarking social vulnerability in the context of the risk management cycle allows risk managers to evaluate any interventions designed to reduce social vulnerability. Social vulnerability is also dynamic in nature, so periodic assessment and mapping can also help to understand how the location of socially vulnerable elements of the population change over time with respect to broader changes in the society.

7.1.2 Limitations of this approach to characterising social vulnerability

Understanding social vulnerability as an interdependent relationship between social characteristics is a new and under-explored science. For this reason, the combinations of social factors used in this study were made in a somewhat *ad-hoc* manner, based on the one hand on existing knowledge of vulnerability and disaster management processes and practices, and on the availability and accessibility of social data (including a paucity of loss data).

The social vulnerability categories used in the study seem appropriate. However, future work should validate these social characteristic combinations with qualitative interviews with social welfare providers. Such interviews should be undertaken in concurrently with the identification and selection of characteristics in order to ensure those characteristics reflect social workers' practical experiences with social vulnerable or disadvantaged members of the focal population. Ideally, these interviews should be the major guide when associating interdependent social characteristics.

Interviews with experts can provide valuable insights on the current condition of a certain community and on past disaster experience. Expert interviews might be conducted with, for instance, local governmental bodies, civil protection representatives, and faith-based and charity organization representatives. Like individual's self-perception of vulnerability, expert opinions are also subjective and strongly influenced by recent experiences.

Regardless which methodological approach is chosen, the gathering of accurate, reliable and accessible data is a major challenge for social vulnerability assessments. Particularly tricky are attempts to analyze people's capacities of response, their relationships, and the overall degree of community cohesion. These factors can strongly influence vulnerability, but their qualitative nature makes them difficult to measure and define, and difficult to integrate into existing quantitative assessments, even though their inclusion should be considered indispensable in vulnerability assessment.

Lastly, the use of what Kuhlicke (2007:119) defines as "classical" indicators– such as demographics, employment, education and income – are nonetheless fundamental in explaining much of the variation of social vulnerability, despite their limitations in capturing the complexity of social vulnerability in reality. Although we talk of social vulnerability "categories" in this report, in fact, these categories are constructed upon a basis of classical indicators (household structure, income, age, nationality, work status, *etc*.).

7.2 Social Vulnerability and Risk Analysis

A conceptual and geographic understanding of social vulnerability is also highly useful in the specific context of risk analysis. This section explores the cost-benefit return on addressing social vulnerability in risk

analyses, and identifies potential for including consideration of social vulnerability in the Swiss Federal approach to hazard risk analysis, KATAPLAN.

7.2.1 Returning to the Risk Triangle: cost-benefit of including non-structural social vulnerability in risk mapping

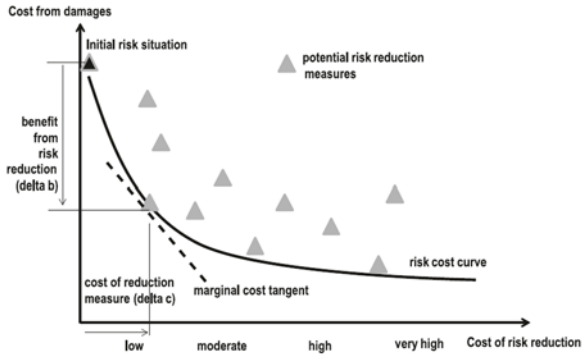

Figure 13: Cost-benefit relationship of risk reducing measures. From Bründl, 2009.

The objective of the Canton of Zürich's flood risk map Risk mapping process has been to close the gap between existing hazard mapping (which has been dissociated) and the development and implementation of risk mitigation action plans. However, such planning can focus only on addressing structural vulnerabilities (among the other risk aspects that are mentioned above). In fact, non-structural vulnerabilities play a greater role in exaggerating the impacts of hazard events (Cutter *et al.,* 2003; Haque and Etkin 2007). Therefore, addressing both structural and non-structural social vulnerabilities simultaneously can potentially have a far more significant return on risk mitigation investments (Figure 13). A working example of a hazard mitigation cost-benefit analysis tool is the 'EconoMe' tool, used to calculate the cost efficiency of civil protection measures (Bründl, 2012).

Of course, knowledge and mapping of hazard extent and exposure of assets are considerably more developed than knowledge about structural and non-structural social vulnerability. However, knowing where social vulnerability exists, and addressing these vulnerabilities through targeted measures in the Integrated Risk Management Cycle offers a cost effective means of reducing risk. In fact, understanding how much risk can be reduced by addressing social vulnerability must be understood and considered in the context of broader spending on risk mitigation and preventive actions. This is especially the case if disasters are a social phenomenon, as identified in the disaster studies literature. Problematically though, it is also important to connect the longer-term impact of reducing social vulnerability on associated risk management measures, like risk communication and household preparedness. To understand whether the investment is rewarded, it's necessary to establish practical metrics for risk communication and preparedness that can be used in evaluations. Nevertheless, existing risk maps provide a useful basis on which to add elements of social vulnerability for a holistic picture of risk.

7.2.2 Incorporating Social Vulnerability into Swiss Risk Analysis: KATAPLAN

If social vulnerability assessments can be incorporated into existing risk maps, then social vulnerabilities should also be addressed in established risk analysis processes in Switzerland. The Federal Office for Civil Protection has established a standard risk analysis process: KATAPLAN (FOCP, 2013). The process involves three primary steps (Figure 14). An assessment of social vulnerability using the technique developed in this study could most sensibly be incorporated at step two (analysis). This risk analysis methodology is used in the large majority of Swiss cantons (Herzog and Roth, 2015).

An important element of the scenario description at step two, is the analysis of the risk. This process should coherently examine both the probability of occurrence and the extent of damage from the potential hazard. Given the strong relationship between hazard impact and social vulnerability, this step should, in future, be informed by social vulnerability assessments. At the very least, the step should be informed by risk mapping that has incorporated non-structural *and* structural social vulnerability information.

This second assessment (B in Figure 14) step in the KATAPLAN process is intended to be undertaken by risk management experts and specialist bodies. The KATAPLAN guidelines specify that decisions here should be guided by existing organizational and expert experiences and statistics. Lastly, the guideline highlights that future development opportunities are to be assessed and included in the risk assessment. This provides perhaps the best opportunity to incorporate social vulnerability mapping into exiting Swiss civil protection activities.

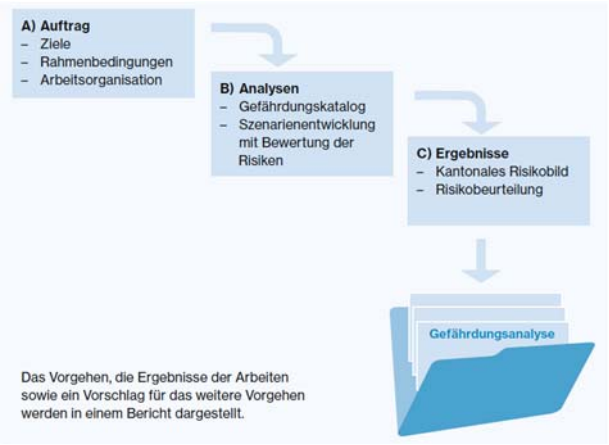

Figure 14: KATAPLAN Cantonal risk analysis process. From FOCP, 2013.

7.3 Potential Data Sources for Future Analyses

During the course of this project, the project team identified a variety of potential data sources for future social vulnerability analyses. While the following data sources were not drawn on in the current study, owing to the detailed data available from the City of Zürich, a geographically broader study would find these datasets of significant utility.

Population Census: available on the Swiss Statistics Office website, it provides up to date information with respect to population demographics and socio-economical condition. Depending on the topic, the timeframe ranges from 2014 to 2016.

Swiss Household Panel: The principal aim of SHP is to observe social change, in particular the dynamics of changing living conditions and representations in the population of Switzerland. It is a yearly panel study following a random sample of private households in Switzerland over time, interviewing all household members mainly by telephone. The survey covers a broad range of topics and approaches in the social sciences. Currently the SHP database holds information on the years 1999 to 2013. The data from the Swiss Household Panel are freely available for the scientific community.

European Social Survey: A program of research to assess population well-being, belief, behavior and perceptions across Europe.

BADAC: An information portal to support research and comparative analysis of public administrations and political authorities in Switzerland. It is established principally as a service to support research and teaching in Swiss cities. The BADAC indicators concern the degree of development of state activities and structures at the level of Swiss cantons and towns (municipalities), and at the national level. Key indicators are broken down by theme, providing direct access to the most recent and important statistical data from the point of view of the administrative sciences.

7.4 Social Vulnerability and Integrated Risk Management: potential uses

This pilot project successfully shows where social vulnerability exists, and this knowledge is valuable in and of itself, even if there is no or very little, underlying risk. As discussed in section 4.5, this information is useful not just in the context of civil protection, but also in the context of social equality, fairness of service provision, and the reduction of disadvantage within a diverse population. Maps, like those produced here, are particularly useful for localized responses to hazard – especially in the context of targeted risk communication and building household preparedness. These aspects of disaster management will likely form the basis of future engagement with the public.

This report has drawn guidance for selecting social characteristics, and mapping their interdependence, from the Swiss Integrated Risk Management Cycle (Figure 3). This has been done to illustrate the direct benefit of social vulnerability mapping for civil protection in Switzerland. Here we describe five hazard management activities that can be directly informed by the methodology developed in this study.

7.4.1 Localized risk communication

Public risk communication is a central component of risk management, and one of the risk manager's biggest challenges. It is widely acknowledged that a well-informed public is often better prepared for a crisis and recovers faster if a crisis occurs (Heath and O'Hair, 2010. On the other hand, risk management, and by extension communication processes, are increasingly complex and technical (Roth *et al*., 2015). This complexity creates issues of understanding and meaning for the public receiving risk messages (Prior and Herzog, 2014). Mapping specific social vulnerability provides fundamental information for the risk manager that can be used to increase public understanding of risk messages on the one hand, and to create risk messages that are meaningful to the specific segments of the public, on the other.

These two components are central to the development of a tailored risk communication strategy. Creating a tailored risk communication approach means mapping out the target audience, with a special focus on demographic and social vulnerabilities that need to be considered. For instance, how should the communication strategy be adjusted to suit particularly vulnerable groups, like those who might have difficulty evacuating, those lacking awareness of risks, or households lacking the capacity to cope with the potential impacts of a hazard? The social vulnerability mapping technique described and tested in this pilot study can be drawn on to support the production, distribution and management of risk information by civil protection authorities in Switzerland. In particular, it can be used to develop risk messages that are sufficiently understandable and usable to allow citizens to engage in collaborative risk management and governance activities. Even more importantly, it is essential for localized risk communication efforts – like town hall meetings, door-to-door information campaigns, letter-box drops, *etc*. – which all require a profound knowledge of the geographical dimension of vulnerability.

Crafting a specific risk message for socially vulnerable groups of the population can also be informed by the social vulnerability mapping approach described here. In order to ensure effectiveness, risk messages should be truthful, frank, and unique. An understanding of the nature and location of pockets of social vulnerability can be directly used to create unique and understandable risk messages for those members of the population that particularly need support. This approach can assist authorities to produce and distribute risk

information that supports citizens' personal disaster risk decision-making by providing comprehensive risk information that can generate self-efficacy among the target population.

7.4.2 Household Preparedness Advice and Support

Social vulnerability is typically negatively related to preparedness, and consequently, disaster management authorities seek to increase disaster preparedness in order to reduce hazard-related vulnerability (Prior and Herzog, 2015). The key benefit that preparation brings to the individual, whatever the hazard, is the ability of such action to mitigate the consequences of hazard activity. Minimizing the consequences of a hazard through effective preparation can contribute significantly to reducing the ultimate effects of hazard activity, and increasing the ability to cope with and adapt to hazard consequences.

One of the key goals of contemporary hazard management is the development of a resilient society (Paton *et al.*, 2000). By promoting preparedness through targeted communication, hazard management authorities can support individuals to effectively and safely deal with situations that are outside their day-to-day experiences (like a hazard event). For example, through local preparedness training, community self-help workshops, *etc*. In terms of reducing vulnerability among those members of a society deemed to be at risk, hazard management actions must be effective and delivered efficiently in a timely and appropriate manner. The social vulnerability mapping approach used here can directly support this process in Switzerland. Social vulnerability information (nature and location) informs the hazard management organization's knowledge of the public's capacity to deal with a hazard, and therefore, the way they can increase capacity when and where it is lacking.

7.4.3 Benchmarking social vulnerability

Past studies have investigated social vulnerability based on the assumption that it is a static characteristic of society. In actual fact, social vulnerability is instead embedded in social *dynamics,* implying some aspect of motion. This project has demonstrated that social vulnerability is dynamic geographically, and the mapping technique could be used to identify the temporal dynamics of social vulnerability in the population.

Understanding both the spatial and temporal dynamism of social vulnerability is useful directly in informing hazard management processes and activities, as this section highlights. Understanding the way social vulnerability changes over time can also allow risk managers to evaluate the effectiveness of any interventions, processes or practices that have been instituted to reduce social vulnerability. This is an important observation, because it stresses the need to look not only at the current situation of an individual (for instance, being unemployed), but also at the temporal continuity of that situation (the fact of being frequently unemployed). It highlights that the possible outcome of a condition can influence other dimensions of a person's life (inability to save money, emotional distress), and their relationship to hazards in their environment.

Thus, a comprehensive assessment of a variety of social vulnberability categories can be used to benchmark social vulnerability in an area, and in relation to specific hazards.

7.4.4 Disaster Management and Spatial Planning

The relationship between disaster management and spatial planning in risk-exposed cities is under-explored. Greiving *et al*. (2006) even point out that the role of spatial planning in risk assessment and management has been overestimated. Conversely, Maduz *et al.* (forthcoming) point out that risk assessment in Switzerland has rarely been integrated into spatial planning at the city level. This is counter-intuitive given the fact that spatial planners should be acknowledging risk when planning city development zoning. The Swiss Federal Council acknowledges that long-term urban development should "take proper, conscious account of risks and natural hazards" (Swiss Federal Council, 2016, p. 18), but it is unclear at this stage how this vision will be incorporated into civil protection processes in the short-term. Even so, the Swiss Federal Office for Spatial Development does acknowledge the necessity to improve alpine spatial development planning in the context of natural hazards associated with climate change (Straumann *et al.*, 2012).

Benchmarking the nature and location of social vulnerability, and the associated spatial and temporal changes associated with this dynamic societal factor, can support spatial planning processes. For instance, mapping this study indicates that a hotspot of elderly women living alone exists in the northern part of the Zürich. Not only is the information useful for evacuation planning, but it can also be used by the spatial planner to plan additional services for these people (relating to, for instance, accessibility, public transport, *etc*.).

Switzerland's National Platform for Natural Hazards (PLANAT) has begun to address risk-based spatial planning (Camenzind and Loat, 2014). While this work has not addressed social vulnerability directly, the authors recognize that high risk areas are not typically those where the threat level is highest, but in areas of residual threat where land use is intensive. It is in these places where social vulnerabilities can act to exaggerate risk. Establishing landuse practices that are adapted to the hazard situation, by combining an understanding of the type of use, its intensity and its susceptibility (including social vulnerability) to damage is a key task of future spatial planning (ARE, FOWG, SAEFL, 2005).

7.4.5 Decision Support: ease of utility

This study details the results of a reasonably fast and easy technique for understanding and mapping social vulnerability. While considerable conceptual effort has been invested in identifying meaningful social vulnerability categories, once identified, finding and

accessing suitable data was less time intensive. Most importantly, Geographic Information System software has developed considerably in the last decade, opening this previously technical mapping process to lay-users.

As a practical decision support tool, this technique represents a valuable addition to the Swiss hazard manager's toolbox. However, it must be recognized as that: a decision support tool. While mapping social vulnerability advances the hazard manager's ability to deliver civil protection services, it is just one tool that must sit alongside many other decision inputs. In some situations (like targeting risk communication, or providing specific support for household preparedness) social vulnerability maps can be of significant value. For other aspects of hazard management (technical hazard prevention) this technique has less relevance.

However, this work demonstrates that social vulnerability mapping is a relatively non-intensive process, requiring limited resources. As such, the process could be readily applied by the civil protection organization without draining limited resources from existing hazard management activities.

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