Chapter 4

Boosting resilience through innovative risk governance: the case of Switzerland

This chapter summarises the country case study findings of boosting resilience through innovative risk governance in Switzerland. After providing an overview of the various natural hazards and their relatively high socio-economic impact across Switzerland, the chapter showcases Switzerland's progress and good practices in disaster risk reduction. The chapter illustrates how Switzerland has developed a forward-looking approach to risk management that is firmly centred on the philosophy that successful risk management requires strong whole-of-society engagement and solid stakeholder coordination mechanisms. Despite the exemplary practices in ensuring multi-stakeholder participation in disaster risk management, the chapter found room to further increase risk awareness for current and future risks to enable continued shared risk financing and successful implementation of the well-developed regulations. Finally, the chapter puts forward recommendations to confront future disaster risk prevention challenges, such as maintaining the stock of protective infrastructure, while ensuring sufficient funding for new investments.

Summary

Due to its varied topography and climate Switzerland is exposed to a number of different hazards. Switzerland is surrounded by the Jura Mountains in the north and the Swiss Alps in the south, separated by the Swiss Plateau in the centre. Its climate varies from near Mediterranean to more temperate. As a result, Switzerland is exposed to a variety of gravitational, climate-related and tectonic hazards that differ in source and impacts depending on where the hazard occurs.

The socio-economic costs of disasters in Switzerland are high. Over the last 70 years, Switzerland's population and inhabited land have increased rapidly, resulting in 22% of its population along with 25% of material assets and about 30% of the country's jobs located in flood-prone areas. Damages from floods, landslides and rockfalls alone average some CHF 310 million annually, single hazardous events such as storm *Lothar* in 1999 and the floods of 2005 have caused damages in excess of CHF 2 billion and CHF 3 billion, respectively. Although earthquakes have a much lower occurrence probability, the damages from a major earthquake could cause damage much greater than that expected from the other hazards.

Key Findings

Switzerland has developed a strong whole-of-society approach to risk management. After a long history of exposure to various hazards, Switzerland has developed an exemplary model of risk management that defines and coordinates key roles for all levels of government, as well as public and private insurance companies, other private sector actors and citizens. Switzerland's approach is centred on the philosophy that the state's efforts are only effective if all other actors are contributing to risk management, both in terms of behaviour and investment. As a result, there has been a significant increase in the capacity to cooperate and coordinate strategies and policies across sectors.

Grounded in a long standing risk management tradition, Switzerland has developed a forward-looking, integrated risk management approach to protect citizens. Since 1848, constitutional laws have been developed to create the basis for public investment in infrastructure, including protective infrastructure. Having evolved from a reactive approach to managing risk that focused on measures ex post of disasters, Switzerland's current forward-looking principles of risk management prioritise soft measures that are nature-based over structural protections, as well as a culture of risk in society instead of a sole reliance of the government to manage risks. These principles employ an all-hazard approach to reduce vulnerabilities and ensure society is aware of, accepts and adapts to residual or remaining risks.

While structural measures are implemented by sub-national governments, they are financed in large part by federal contributions. Sustaining the level of financing necessary to continue to increase protection and maintain the large stock of existing protective infrastructure will be a challenge moving forward. Moreover, while the wide-spread use of hazard maps in land-use planning has effectively reduced damages in high-risk zones, more can be done to strengthen regulations in lower-risk areas.

Key recommendations

Strengthen the evidence base on the potential occurrence and costs of disasters

- Enhance understanding of the possible linkages and cascading effects of natural disasters and risks highlighted in the Swiss national risk assessment including pandemics, power outages or nuclear accidents.
- Establish a more systematic approach to disaster loss data collection, especially with regard to socioeconomic impacts, across all cantons, including those where the natural hazard insurance is not organised by public insurance companies.
- Expand the current natural hazards (WSL) database to also include data on the negative socio-economic impact of disasters stemming from metrological and earthquake hazards, and consider including data on indirect damages.

Continue to strengthen risk governance mechanisms across all involved levels

- Ensure that disaster risk management is tailored to the appropriate spatial area, which might require strengthening cross-jurisdictional disaster risk prevention actions and transboundary cooperation in risk management.
- Evaluate the activities of PLANAT and LAINAT more regularly and potentially consider to further opening up their governance structures.

Maintain an integrated, whole-of-society approach to the management of structural and non-structural measures

- Strengthen the maintenance of protective infrastructure, so to ensure the level of protection for which the existing infrastructure was conceived initially. Maintenance investments should ideally not come at the expense of future protective infrastructure needs.
- Efforts to build a central database on the level of maintenance of existing protective infrastructure could be accelerated to enable effective prioritisation of maintenance investments and inform budgeting for maintenance finance needs in the medium term.
- Continue closing the gaps in availability of local hazard and risk assessments to inform disaster risk prevention and mitigation measures needed for new construction projects and older buildings alike, ensuring their harmonisation across municipalities.
- Stronger focus of disaster risk prevention efforts especially in areas of lower hazard level, where more than half of the damages from disasters currently occur.
- Give more attention to seismic hazard assessments and building code enforcement, especially in terms of their potential trigger and cascading impacts. Although

comparatively rare to other hazards, earthquakes can potentially cause significant negative socio-economic impacts.

- Ensure that high levels of risk awareness are maintained and streamlined across hazards. An evaluation of the effectiveness of past and ongoing risk communication campaigns, including those managed by private sector actors such as insurance companies, could help ensure their efficiency in light of changing risk landscapes and channels of communication.
- Evaluate the actual take-up of disaster risk reduction measures across societal actors more systematically to inform future activities that aim at increasing and complementing whole-of-society contributions to disaster risk reduction.

Continue fostering a whole-of-society approach to risk financing

- Improve the picture of the flow of financial contributions by the different actors by centrally and regularly collecting funding information across cantons and different non-governmental actors to better target and prioritise spending and to avoid that expenditure by different actors are undermining each other.
- To meet future disaster risk prevention investment needs, it is important to engage in longer-term financial needs assessments and financial planning to avoid an increase in vulnerability to citizens and assets from the impacts of disasters.

Introduction

Geographically shaped by the Alps in the South and the Swiss Plateau and the Jura in the Northwest, Switzerland has a varied topography and climate. During the last 70 years, Switzerland's population has nearly doubled and increasingly expanded into risk-prone areas. The rise in population was accompanied by an expansion of both industrial and residential areas, about a quarter of which are today located in flood-prone areas. Alongside floods, which account for the biggest part (36%) of damages (covered by insurance companies) observed in the country, Switzerland faces a variety of different hazards, ranging from gravitational and meteorological hazards to tectonic hazards, including earthquakes.

Switzerland has pursued a forward-looking, whole-of-society approach to risk management anchored in a philosophy that the state's effort is only effective if all stakeholders are contributing their share. Due to a long history of solidarity in policy making, Switzerland has an effective system of cooperation and shares the management of risks between all levels of government. The federal government is in charge of guidance and policy setting while local governments lead efforts in providing safety and implementing disaster risk reduction projects, with cantons supporting local levels by providing support and resources for implementation. Moreover, Switzerland includes an inclusive set of public and private actors in its risk governance structure. For example, as a result of a mandatory insurance mechanism, insurance companies play a key role in providing loss compensation, disaster risk prevention and loss mitigation while also placing the onus on citizens to participate in risk management through informing them of their responsibilities and enforcing this when administering pay-outs. Public and private actors are tied together by two coordination platforms that provide strategic and operational support.

This present case study report assesses the progress, achievements and potential challenges for Switzerland's disaster risk prevention system, with a particular emphasis on disaster risk prevention and mitigation, from a decision-making, implementation and financing perspective. The objective of this analysis is to highlight good practices as well as challenges Switzerland may face in fostering its whole-of-society approach to disaster risk prevention and mitigation, where the responsibility for disaster risk prevention and mitigation is shared between both government and non-governmental actors.

This study builds on previous work of the OECD (2014a) that sought to identify effective ways for OECD countries to boost their resilience against extreme disaster events, which informed the OECD Recommendations on the Governance of Critical Risks (OECD, 2014b). In a cross-country comparative study, of which this case study is one selected country, the OECD assessed and compared disaster risk prevention and mitigation systems across a set of OECD countries, based on the framework and recommendations previously developed. The objective of the study was to identify good practices and challenges across case study countries as they attempt to achieve greater resilience through a whole-of-society approach to disaster risk prevention and mitigation. The case study of Switzerland informs the comparative analysis and allows lessons to be shared widely to inform OECD countries' disaster risk prevention policies and practices.

This study analyses whether the institutional roles, responsibilities, financial setup and incentives of Switzerland's core disaster risk prevention institutions and actors are aligned so that each actor's expected contribution to a whole-of-society approach to disaster risk prevention is carried out adequately. Section II provides an overview of Switzerland's hazard landscape and its socio-economic relevance. It includes an assessment of recent significant disasters and the overall trend in socio-economic losses from disasters in Switzerland. Section III provides an overview of the risk governance structure guiding Switzerland's disaster risk prevention and mitigation efforts. Section IV and V assess the management of structural and non-structural disaster risk prevention and mitigation measures as well as current financial frameworks that contribute to fostering a whole-of-society approach to risk management. Section VI provides a final assessment and recommendations.

Switzerland's hazard sources and risk exposure

Section Highlights

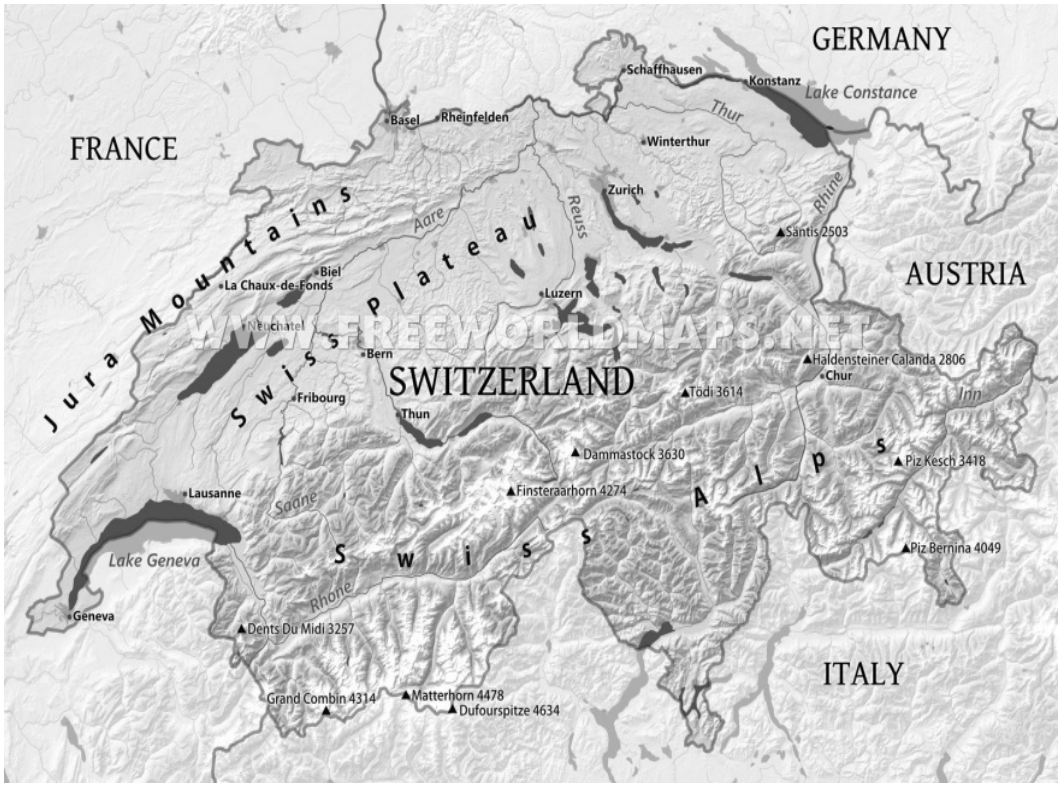
- Switzerland is exposed to a range of natural hazards, from Alpine hazards such as avalanches, debris flows, landslides and rock falls to large river floods, storms, earthquakes and heatwaves. Switzerland's population and inhabited land have increased rapidly in the past 50 years resulting in 20% of its population living in flood-prone areas, along with about 30% of the country's jobs and 25% of assets worth an estimated CHF 840 billion.
- Damages from flood, landslides and rock falls alone average some CHF 310 million annually. Highly destructive events such as storm Lothar in 1999 and the floods in 2005 significantly drive damages, respectively causing a total of CHF 2 billion and CHF 3 billion.
- Although earthquakes occur much less frequently, they would be the source of the greatest expected amount of negative socio-economic impacts. A comparable event to the 1356 Basel region earthquake is estimated to cause some CHF 50 to CHF 100 billion in damages today.
- Switzerland gathers information on socio-economic losses in a central database and has embraced a forward-looking, multi-hazard approach to risk management
- Switzerland shows exceptional awareness for future expected changes that could alter natural disaster profiles, which includes climatic changes but also changes in underlying risk factors, such as patterns in socio-economic development and society's risk culture.

Hazard sources

Switzerland is a landlocked country, geographically divided between the high-altitude Alps in the central-south, the Prealps and the relatively flat Swiss Plateau between Lake Geneva and Lake Constance in the northern half and the hilly Jura Mountains in the northwest. Most of its 8 million inhabitants live in the northern half of the country (Figure 4.1). The Swiss Alps range from low to relatively high, and include a large number of mountain peaks that reach beyond 4,000m above sea level. Switzerland's extensive glaciers feed several major European rivers, such as the Rhine, Inn, Ticino and Rhône. Switzerland's Lake Geneva, Lake Constance and Lake Maggiore are some of

Europe's biggest fresh water reservoirs. Its climate is equally varied, from near Mediterranean in the south to more temperate in the rest of the country.

Figure 4.1 Switzerland's topography



Source: http://www.freeworldmaps.net/europe/switzerland/switzerland-physical-map.jpg

Its distinct topography and regional climatic variations make Switzerland exposed to a number of different hazards, including gravitational and water-related, climate-related, and tectonic hazards (Table 4.1). Hazards related to volcanoes, meteoroids or space weather occur very rarely and are thus not considered prevalent natural hazards in Switzerland.

Switzerland's mountain ranges provide a meteorological divide that impedes natural hazards from spreading across the entire country. This diminishes the likelihood of experiencing a major loss event that affects all of Switzerland.

Switzerland's topography also affects the same source of hazard differently. Floods form from a number of possible causes, including brief heavy bursts of precipitation, long-lasting rainfall, drastic snow melt, or a combination of these processes. In regions with steep hills, the subsequent flood forms primarily as a body of flowing water, which creates mud and debris flows as well as overbank sedimentation. Conversely, ensuing lowland flooding causes rivers, lake and groundwater discharge, which produces damaging large-area flooding, localised flooding, bank erosion or concentrated water run-off.

Table 4.1 Types of natural hazards prevalent in Switzerland

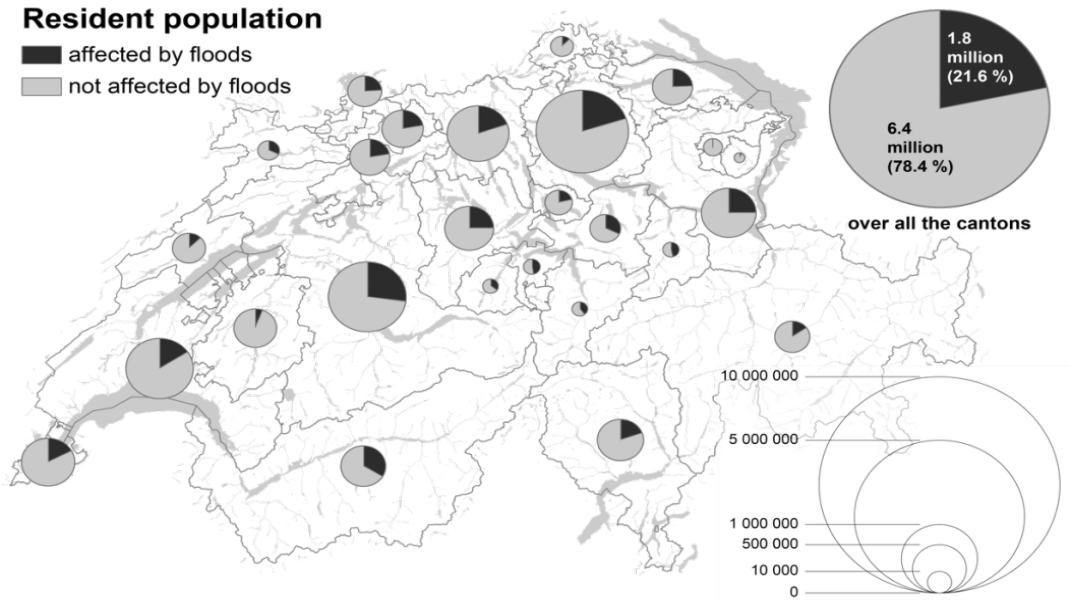
Natural hazard category	Types of natural hazards
Gravitational hazards	• Different types of snow and ice avalanches • Water-related hazards: floods, bank erosions, debris flows, surface water, etc. • Mass movements: rock falls, landslides, permanent or spontaneous slides, etc.
Climate-related and meteorological hazards	• Extreme temperatures (e.g. heatwaves) • Storms, extreme precipitation, hail, freezing rain, snow storms, lightning strikes, wild fires, etc.
Tectonic hazards	• Earthquakes, induced landslides or rock falls, etc.

Source: FOEN (2016b)

Disaster risk exposure

Switzerland has undergone tremendous socio-demographic changes in recent decades. Its total population increased from 4.5 million people in 1946 to over 8 million in 2016. To accommodate this population increase, housing and transport infrastructure grew significantly over the past half-century. Between 1985 and 2009 the built-up area in Switzerland increased by 23.4%. This is not only due to the absolute increase in population numbers, but also due to the increased average share of land that is used by people. To gain land for settlement purposes, agricultural land was given up.

Figure 4.2 Shares of population that live in flood-prone areas across Switzerland

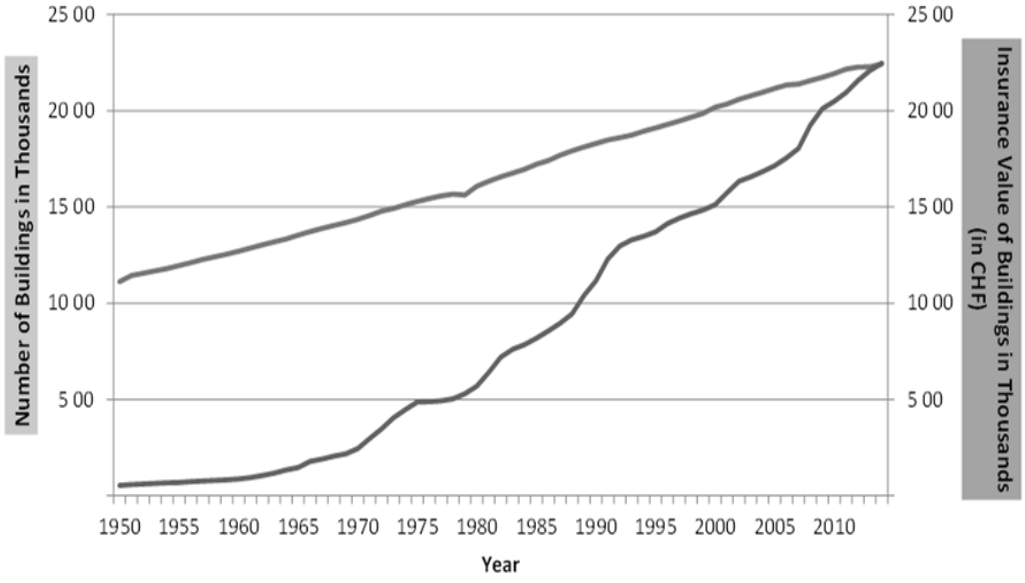


Source: FOEN (2016c) based on Aquaprotect flood zones and population data from the Swiss National Statistical Office

As a consequence, damage potential has increased continuously. Figure 4.2 indicates that around 22% of the Swiss population currently lives in flood-prone areas. Around 25% of material assets are located in flood risk areas, which have an estimated economic value of CHF 840 billion[1]. With about 30% of Switzerland's jobs also located in areas prone to flood risk, a significant part of the country's economic value creation takes place in areas at risk from flooding.

Similar to the increased expansion of land for settlement purposes, the assets that were created have increased Switzerland's exposure to natural hazards significantly. Figure 4.3 shows that the number of insured buildings has increased continuously since 1950. However, their value has grown even more rapidly, which is due to more expensive building materials being used in construction as well as due to the augmentation in the value of the contents of houses and other types of buildings (FOEN, 2016b).

Figure 4.3 Number and insurance value of buildings covered by Public Insurance Companies for Buildings 1950-2014



Source: IRV (2016)

Socio-economic impacts of past disasters

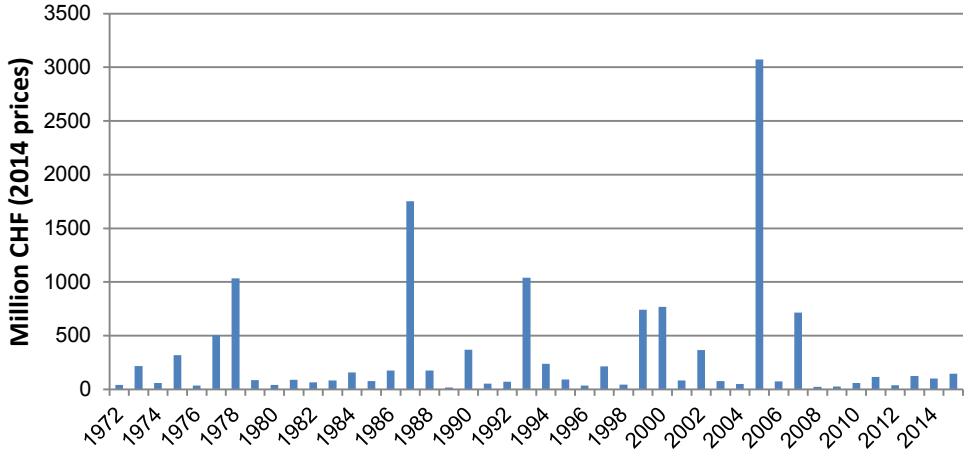
Calculating and recording the socio-economic impacts of disasters is useful in many ways. It tracks trends in social and economic losses over time, informing risk managers whether their risk management policies have been effective in reducing risks and decreasing losses over time. It can also support the prioritisation of disaster risk reduction investments by indicating the areas that are most vulnerable to disaster events.

Economic losses can be distinguished by direct and indirect economic losses. Direct economic losses reflect the monetary value of total or partial destruction of physical assets in the affected area. Indirect economic losses reflect the declines in value added as

a consequence of direct economic loss and/or human and environmental impacts (UNISDR, 2015).

For certain disasters, the number of fatalities by disaster event has been collected as early as 1812 (Badoux et al., 2016). Systematic recording that includes economic loss accounting did however not start until the 1970's. In 1972 the Federal Institute for Forest, Snow and Landscape Research (WSL) was charged by the Federal Office for the Environment (FOEN) with the task of systematically recording both social and economic disaster losses in a central database. Since 1999, the FOEN has financially supported the WSL to maintain the database[2]. Starting out by systematically collecting data on storm damage in Switzerland since 1972, the WSL now takes damage caused by floods, debris flows, landslides as well as (since 2002) rock falls into account. Damage resulting from other hazards, such as avalanches, snow pressure, earthquake, lightening, hail, windstorm and drought are however not noted in the database. The recording is based on newspaper articles for smaller events and official data from cantons and insurance companies for larger events. Damage records are relatively complete for the hazards listed above, particularly in regards to recorded insurance claims, facilitated by the mandatory natural hazard insurance for buildings and content. In 19 of Switzerland's 26 cantons, public insurance companies keep detailed records of insurance claims of past disaster events. While the records kept are useful and rather comprehensive, they do not come without uncertainties. The information needed to update the database is not always available or complete, as not all damage-causing events are included and as the quality of reporting may differ from event to event. This is particularly relevant when analysing smaller events, whereas major events that dominate yearly losses are rather well accounted for.

Figure 4.4 Damages from floods, debris flows, landslides and rock falls (1973-2015), adjusted for inflation, based on 2015 prices



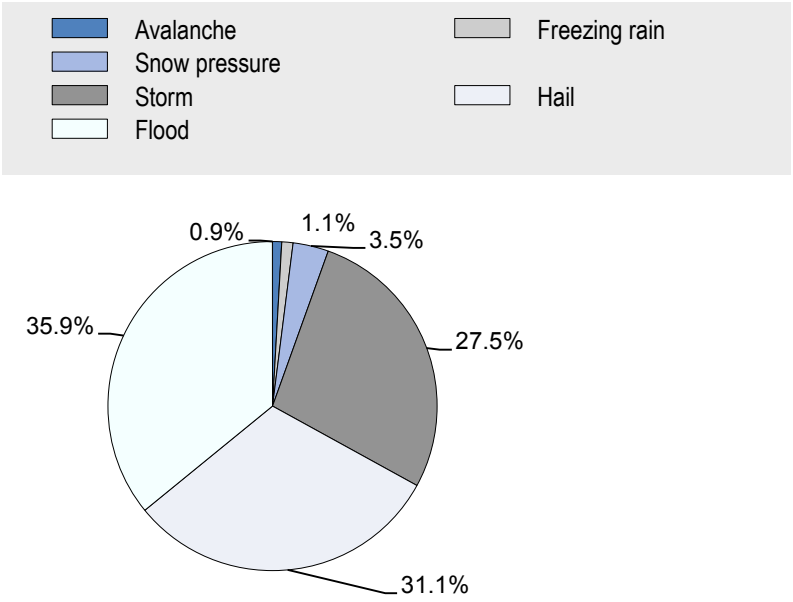
Source: FOEN (2016c), www.bafu.admin.ch/umwelt/indikatoren/08596/08599/index.html?lang=de

In terms of economic losses, a total of nearly CHF 14 billion in economic losses were caused by floods, debris flows, landslides and rock falls in Switzerland between 1972 and 2015. This corresponds to an annual average damage of about CHF 310 million. About half of that was caused by 5 major loss events (Figure 4.4). The floods in August 2005 caused CHF 3 billion in damages alone. They were a result of several days of heavy

precipitation in the north side of the Alps causing debris flows, landslides, bank erosions, and large areas of flooding of the low lying valley areas.

Figure 4.5 demonstrates that 36% of damages (those covered by insurance companies) were caused by flood, followed by hail (31%) and storms (27.5%). Direct damages from avalanches, snow, landslides and rock falls have been relatively small, with only about 5.5% of total recorded damages.

Figure 4.5 Average share of damages covered by public insurance companies for buildings, by hazard 1995-2014

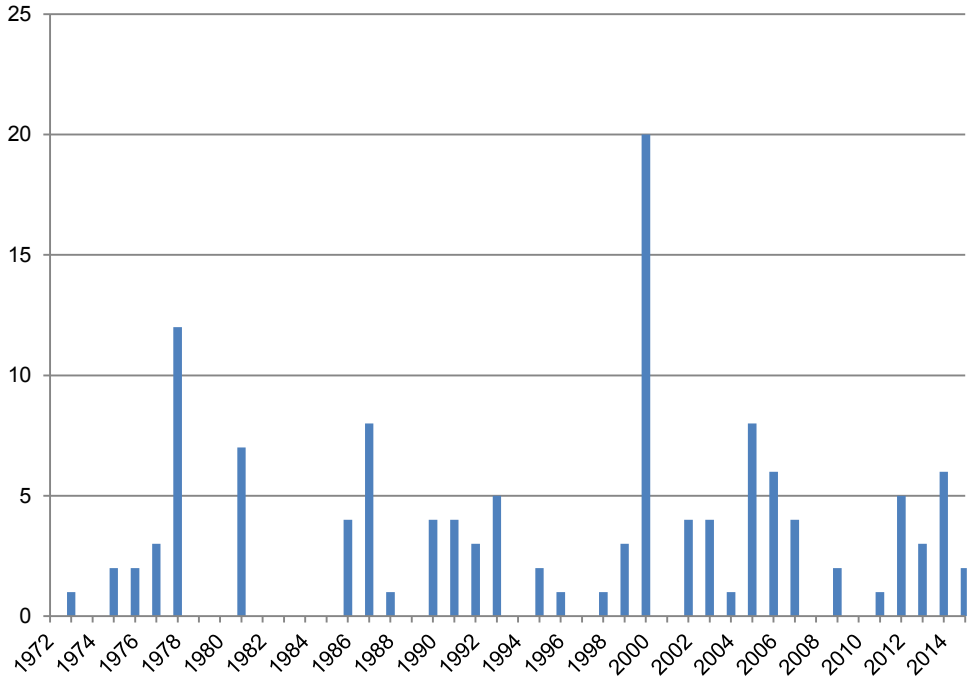


Source: IRV (2010); only based on losses to buildings

Hailstorms, especially in the northern foothills of the Alps and in southern Ticino, can cause considerable damage, such as in the summer of 2009 when hailstorms caused CHF 314 million in direct damage (IRV, 2012a).

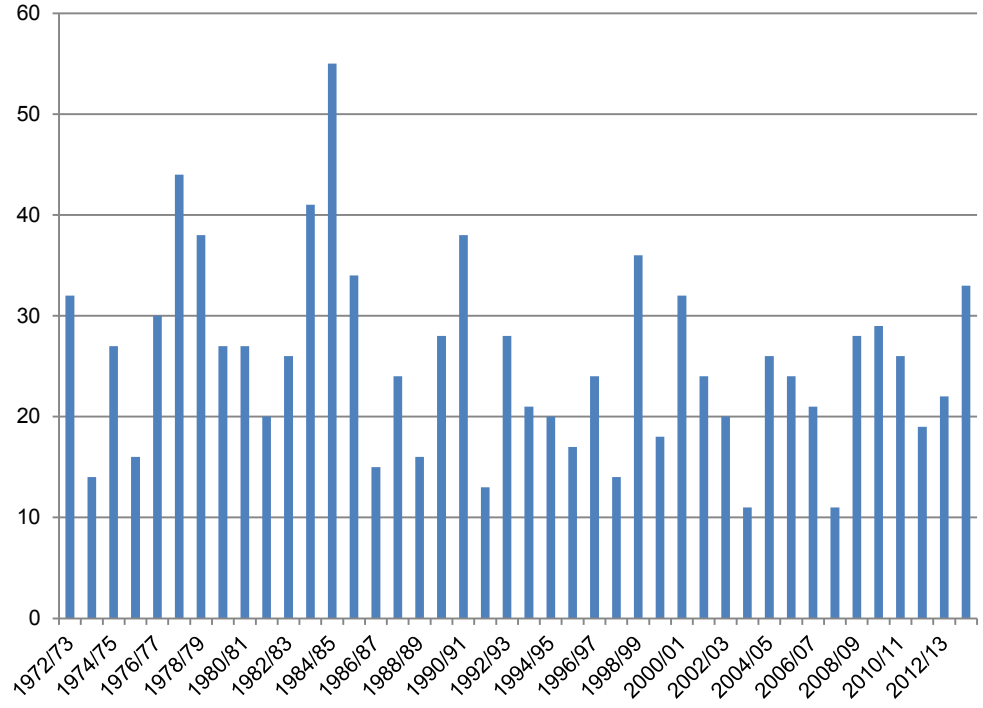
In terms of fatalities, heatwaves have caused the highest such number in the recent past. The 2003 heatwave caused nearly 1,000 deaths and most recently, during the summer in 2015, 800 people lost their lives due to extreme heat (BAFU, 2016). Other hazards have caused considerably less, and continuously less, fatalities in the recent past. Floods have caused 52 fatalities between 1972 and 2015, debris flows 21 and landslides 40. Rock falls have caused 16 deaths since recording started in 2002 (Figure 4.6). Fatalities from floods have shown a decreasing trend since the 19th century. Avalanches cause an average of 25 fatalities annually, whereby the large majority is due to recreational activities off the secured slopes (Figure 4.7). For avalanches, the WSL has systematically recorded fatalities since 1936/37 as mandated by the Federal Office for the Environment (FOEN), whereas recording for fatalities from other hazards dates only goes back to the 1970's. Avalanche fatalities are recorded directly by the institute's staff on the basis of the hydrological year (October until September).

Figure 4.6 Fatalities caused by floods, debris flows, landslides and rock falls (1815-2015)



Source: FOEN (2016b)

Figure 4.7 Fatalities caused by avalanches (1972/73 – 2013/14)

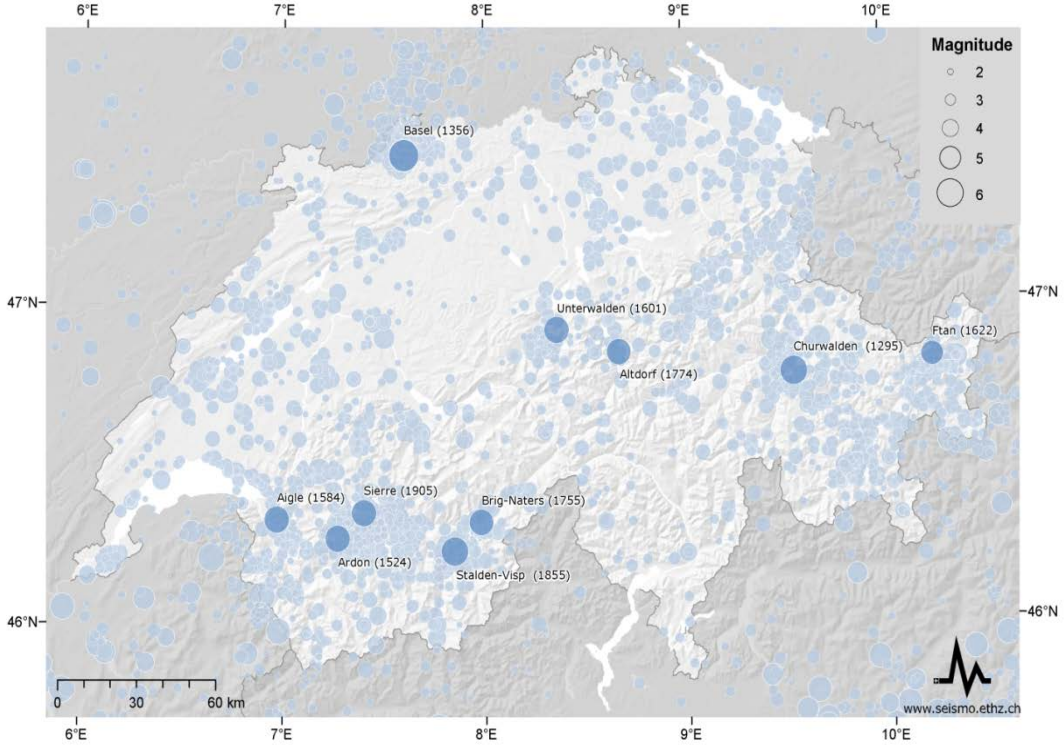


Source: FOEN (2016b)

Major earthquakes have occurred rarely in Switzerland's history, but they could cause a large amount of damage and have caused comparatively high fatality rates in the past. The 1365 earthquake in the Basel region is for example reported to have caused up to 1,500 deaths, though sources vary significantly. Later earthquakes, such as the Unterwalden quake in 1601 and the Stalden-Visp quake in 1855 are reported to have caused major damages (PLANAT, 2004b; SSV, 2010). A comparable earthquake of the Basel region quake in 1356 would for example result in damage of CHF 50 to CHF 100 billion today (SED, 2016). A comparable event in Unterwalden or Visp is estimated to cost up to CHF 21 billion if it occurred today (SSV, 2010). Figure 4.8 shows the regions with the highest earthquake hazard are the Valais, the Basel area and the Canton of Grisons. Large earthquakes could, however, occur anywhere in Switzerland.

Figure 4.8 Earthquakes in and nearby Switzerland.

Shown are the 10 largest events of the last millennium (dark circles, with location and year) as well as all events with magnitude 2 and above between 1975 and 2016 (light circles).



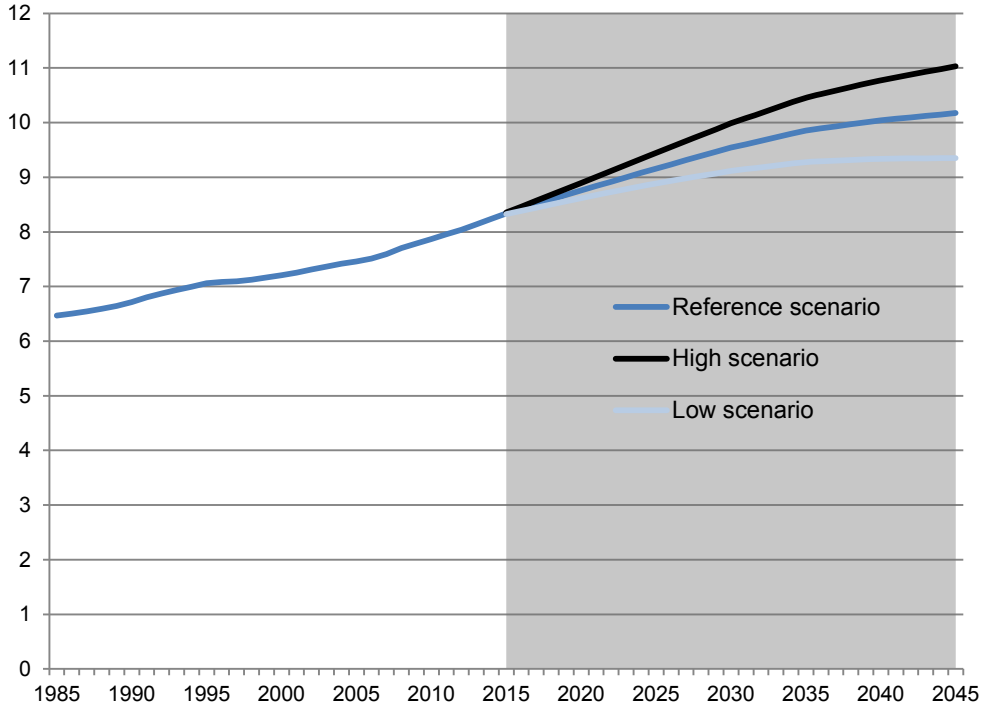
Source: SED (2017), http://www.seismo.ethz.ch/en/knowledge/earthquake-country-switzerland/historical-earthquakes/the-ten-strongest/

Switzerland shows exceptional awareness about the importance of future changes to the exposure to natural hazards. In all its strategies and evaluation of its current systems, the importance of future changes in risk patterns is noted. The natural hazard management strategy elaborated by PLANAT (PLANAT, 2004a) highlights factors that may change future risk exposure, such as mobility, the size of population (Figure 4.9) and settlement areas as well as the increasing value of housing assets. It further highlights the vulnerability arising through inter-connected economies that rely on communication channels. Furthermore, climatic and weather changes are highlighted along with changes

in the socio-political sphere. The latter could include changes in the ways through which society deals with risks, based on underlying values, risk perception and readiness to take risks.

Climatic change has increasingly become a focus area. Higher average temperatures and higher glacier melting rates have increased the awareness of climatic change in Swiss society and politics, illustrated for example by the creation of dedicated research bodies, such as the forum for climate and global change (ProClim)[3] (FOEN, 2012a; FOEN, 2016a). The inclusion of climate change aspects in natural hazard modelling has emphasised the importance of planning and preparing for extreme events, as well as climate change as a source of identifying potentially new hazards (FOEN, 2016).

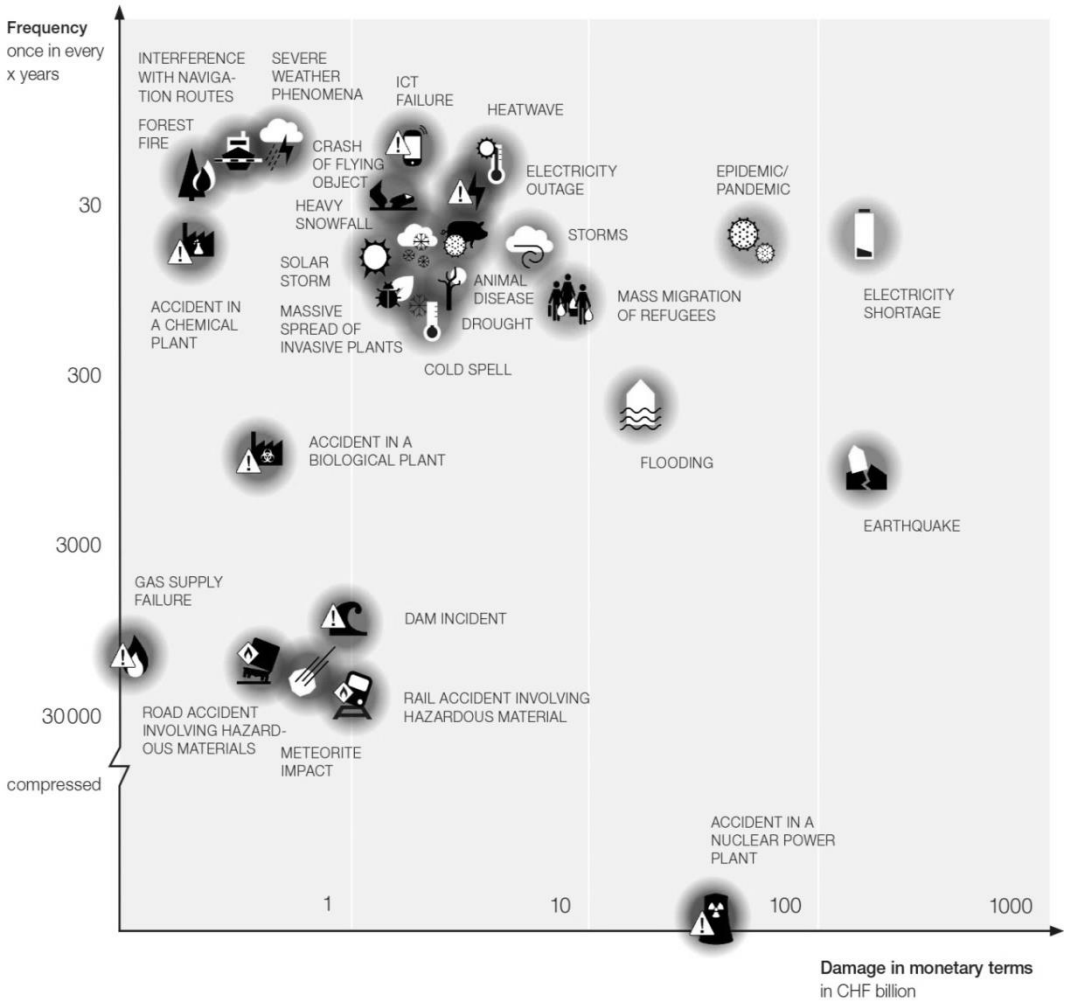
Figure 4.9 Switzerland population projections 2015-2045 (in millions inhabitants)



Source: Federal Statistical Office (2016):
http://www.bfs.admin.ch/bfs/portal/de/index/themen/01/03/blank/key/ent_erw.html

In a broader context, natural disasters have to be put in perspective with other risks that the Swiss national risk assessment has highlighted including pandemics, power outages or nuclear accidents (FCOP, 2015). Figure 4.10 shows that other, man-made disasters such as pandemics, power outages or nuclear accidents could cause damages between CHF 100 to 1 000 billion, albeit a much rarer expected return period of 1 500 – 30 000 years.

Figure 4.10 Estimated frequency and damage of major disasters in Switzerland



Source: FOCP (2015a), http://www.preventionweb.net/files/submissions/47467_katastrophenundnotlagenschweizreport2015.pdf

Conclusion

Switzerland has taken a forward-looking approach to managing the risks it faces and increasingly puts natural disasters in perspective with other risks and has a high level of awareness and alertness about future changes to disaster risk patterns. Switzerland has also achieved a remarkable level in terms of comprehensiveness and quality in recording disaster events, including their social and economic impacts. Whereas some records, especially for smaller disaster events, rely on newspaper articles, larger event records are based on rigorous disaster evaluations. The most systematic records in terms of economic impact data rely on information gathered through compensation payments to individuals and businesses by public insurance companies for buildings in the event of a disaster. This information has been provided consistently and therefore allows for a relatively good understanding of trends in disaster impacts over time, even though for the time being the duration of records may not yet be long enough to confirm trends. Even though

earthquakes occur much less frequently, Switzerland has made an effort to estimate its past economic impacts, which may be used to create future projections of their potential negative socio-economic impact. There seems to be a high level of awareness and alertness about future changes to disaster risk patterns, both from a socio-economic development perspective and a climate risk perspective. Works are underway to understand both patterns more closely and, at the local level, integrate potential implications into risk management planning and implementation.

To consolidate the extensive evidence that is available on the losses caused by different hazards, it is recommended to collect data in a single, multi-hazard national repository for information on social and economic losses of past disaster events. The database administered by the Federal Institute for Forest, Snow and Landscape Research (WSL) is an excellent starting point for this, but could be expanded in terms of hazards covered to also include damage caused by metrological hazards. An inclusion of indirect economic losses, which especially in the context of OECD countries can account for losses much greater than direct losses, could also provide a useful addition to the data already collected by the WSL.

Risk Governance Structure of Switzerland

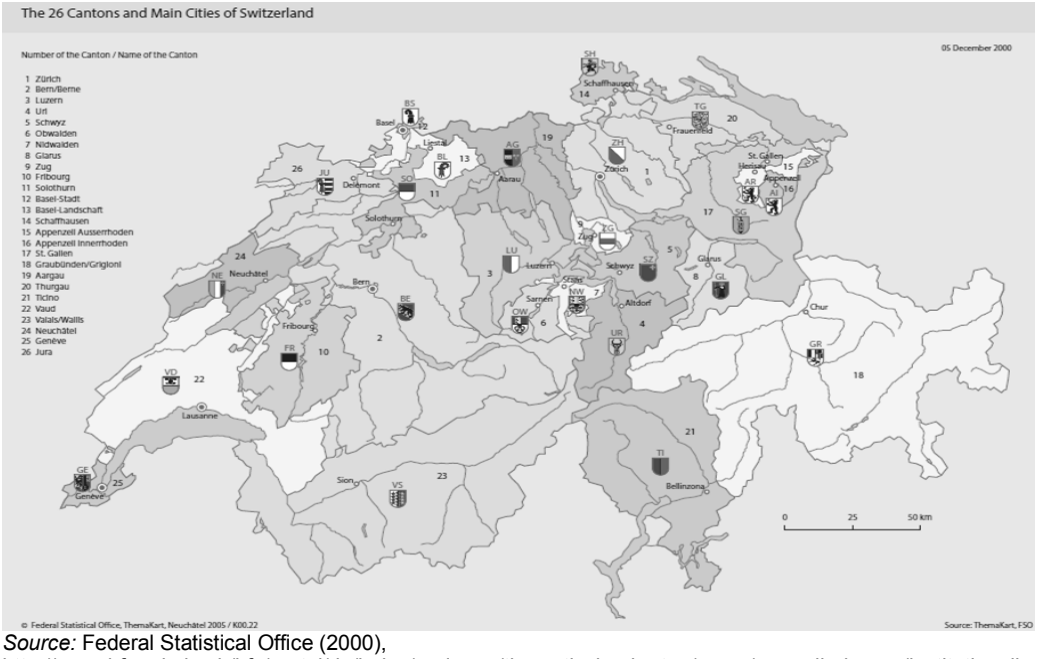
Section Highlights

- Like most policy domains in Switzerland, disaster risk prevention management is a shared task between all levels of government: the national level has guidance and policy setting functions, the local level is in the drivers' seat for providing safety and implementing disaster risk reduction projects in their communities and the cantos ensure and accompany the local levels in the implementation process.
- Switzerland is a good practice example in terms of embracing a whole-of-society approach to managing disaster risk reduction. The government's interventions are deemed effective only if private actors contribute their share to reducing risks through risk-adapted behaviour and individual disaster risk reduction investments. Insurance companies play a key role in translating, informing and communicating about the expected roles of private sector actors and individuals.
- The Swiss direct democratic governance tradition has positively influenced disaster risk management, emphasising awareness raising and building acceptance for disaster risk reduction investments from the bottom up. Lengthy consultation processes have - more often than not - resulted in more efficient and effective disaster risk reduction investments.
- Multi-stakeholder platforms like PLANAT or LAINAT have provided an effective and inclusive approach to bring actors in disaster risk management together to coordinate their actions. To further ensure their relevance and effectiveness, a regular and independent evaluation could be carried out considering, for example, whether their governance structures (in the case of PLANAT) could be opened up to include civil society stakeholders.
- The large and diverse number of research institutions working on natural disasters (including WSL, ETH, University of Bern, etc.) has contributed to the high quality of disaster risk management practice in Switzerland.

Switzerland is a federal, direct democratic country that has four dominant languages: French in the Western part of the country, German in its centre, Italian in its south and Rhaeto-Romanic in the East. There are three layers of government: national, cantonal (*Kanton*) and local (*Gemeinde*). There are 20 cantons and six half cantons (and 2 324 municipalities) with their own constitution and parliament, judiciary and executive powers (Figure 4.11). The cantons therefore have strong powers compared to sub-national levels in other federally-organised countries. As a consequence, the role of municipalities can differ across cantons, depending on the power that is granted to them by the cantons.

Responsibilities for disaster risk management are equally shared across levels of government. The local municipalities are the first in line, responsible for protecting against hazards that threaten the security of its population. The national government supports this process by providing policy guidance and recommendations, but also by co-financing protective infrastructure investments. The cantonal governments ensure that national level guidance is implemented at the local level and provide support and resources for the implementation process. Solidarity has been viewed as a cornerstone to successful disaster risk prevention management as costs of disasters and disaster risk interventions are unequally distributed across Switzerland.

Figure 4.11 Map of the 26 cantons of Switzerland



Source: Federal Statistical Office (2000), http://www.bfs.admin.ch/bfs/portal/de/index/regionen/thematische_karten/maps/raumgliederung/institutionelle_gliederungen.parsys.0002.PhotogalleryDownloadFile2.tmp/k00.22s.pdf

In the following sections, the main legal framework instruments as well as the key actors in disaster risk prevention management will be outlined so as to provide an overview of the governance set-up in Switzerland. This understanding is essential for evaluating the effectiveness and efficiency of the different risk management functions in a subsequent step. The following overview will first present the different legal

frameworks that guide the government's role and responsibilities in disaster risk management before the different actors and their respective responsibilities are discussed.

Legal instruments

The Swiss national constitution was last revised in 1999. It increased the role of the cantons in public policy making and implementation in general. The national government is thereby obliged to give significant freedom to cantons to decide the way they implement national policies. The management of some natural hazards and related instruments is anchored in the national constitution:

- Water-related hazards: the constitution highlights that the national government has the responsibility to protect people and their assets from water-related hazards.
- Avalanches, landslides or rock falls, but also storm and fire hazards: the constitution can be used as a basis for determining national responsibilities as well, but more indirectly. It obliges the national government to preserve the protective and economic functions of the forests. The constitution thereby only relates this risk management function to maintaining and protecting the forest through afforestation (FOEN, 2011).
- Earthquakes and hail: There are no national responsibilities anchored in the constitution.
- The agriculture law stipulates that agricultural activities can contribute to the protection against natural hazards, even though no concrete measures are mentioned.

The translation of the constitutional rules into the sector-specific legal instruments varies. For example, with regard to water-related hazards, the national government only partly translated its role that was determined in the constitution. In the Federal Law for Water Engineering (*Bundesgesetz über den Wasserbau*) the role for the national government focuses on the determination of some framework conditions that stipulate fundamental rules only. With regard to its role in managing risks from avalanches, landslides or rockfalls, the national government interpreted its role more broadly than what the constitution determines for it. In the Federal Law of Forestry (*Bundesgesetz über den Wald*) the national government can prescribe protection measures in areas where the hazards originate, such as the incipient crack of avalanches or landsides that might lie outside of forest areas and hence necessitate other technical solutions than afforestation that was initially mentioned in the constitution (FOEN, 2016a).

Several other national laws refer to the protection against natural hazards, including the Meteorology and Climatology Law (*Bundesgesetz über die Meteorologie und Klimatologie*), the Civil Protection Law (*Bundesgesetz über den Bevölkerungsschutz und den Zivilschutz*), the water protection act, the nature and patrimony law, the cantonal spatial planning laws, the early warning directive, the emergency management directive, the railway and national roads laws, or the insurance laws. In addition there are cantonal legislations and directives.

Who are the responsible actors

Switzerland is a role model in terms of having developed a whole-of-society approach to disaster risk prevention management. Key roles for disaster risk prevention

management are shared by the different government levels, but also by insurance companies, private sector actors and citizens. Switzerland's approach is anchored in the idea that the state's efforts are only effective if all other actors are contributing their share to disaster risk prevention management, both in terms of risk-adapted behaviour, but also in terms of investments in individual self-protection measures. The insurance companies play a key role in translating, informing, and communicating about these expectations to private sector actors and individuals, as well as providing technical and financial support for such investments. Private sector companies play a major role in hazard and risk assessments, in the development of protection schemes and in monitoring and early warning processes. The Natural Hazard Experts Switzerland *(Fachleute Naturgefahren Schweiz*, FAN)[4] is an important association with approximately 450 members from the hazard and disaster risk reduction business (Figure 4.12). Through the publication of reports and the organisation of expert meetings FAN contributes to further advancing Swiss disaster risk prevention efforts and the cooperation of stakeholders from various backgrounds.

Table 4.2 Responsible actors and their tasks in natural hazard management in Switzerland

National & cantonal governments	Municipalities	Insurance companies	Associations	Private sector & citizens
Legal frameworks	Land-use planning & building codes	Providing financial protection of potential damages	Provide the basis for building codes (such as architects or engineers associations)	Natural hazard-based constructions and object-specific protection measures
Public infrastructure, spatial planning and cantonal police	Construction of structural protection measures	Insurance services during disasters	Recommendations and advice	Personal and business preparedness (e.g. emergency plans)
Informing citizens	Safety, law & order	Prevention measures that reduce damage potential		Behaviour during a disaster
Emergency management: preparedness, monitoring, early warning, disaster management	Emergency services	Information and advice (for house owners)		Contributions to hazard and risk assessments, development of protection schemes or in monitoring and early warning

Source: FOEN (2016a)

The following section provides an overview of the role of the most important federal and sub-national actors as well as the one of insurance companies and other coordinating platforms in Switzerland.

Sub-national responsibilities

Given the above-mentioned subsidiarity principle, Switzerland's local municipalities are the first in line for risk management. They are responsible for protecting their citizens

against potential threats to their security. Hence, local authorities have a large number of responsibilities in terms of natural hazard management, differing however from one canton to the other. In the Canton of Bern, for example, the municipalities have the following responsibilities (AG NAGEF Bern, 2013):

- Communal land-use planning;
- Building permissions;
- Identifying and assessing prevailing natural hazards in their territory;
- Managing prevailing risks, in terms of reducing them and avoiding exposure to them through local measures;
- Formulating emergency preparedness measures; and,
- Evaluating security measures periodically.

Municipalities are accompanied in this process by cantons that are charged with enforcing laws and providing support for:

- Developing hazard zone maps (quality assurance and approval of hazard maps developed by municipalities);
- Implementing and financing of prevention and mitigation measures, including their operation and maintenance (which includes a periodical survey of the conditions of infrastructures and the approval of maintenance and rehabilitation works);
- Implementing and financing of emergency preparedness measures, especially providing guidance, supervision and technical approval or emergency management plans; and,
- Developing planning measures at the regional scale as well as cantonal emergency management.

The federal level supports municipalities and cantons through:

- Developing legislation and policies;
- Providing recommendations and guidance for the management of natural hazards;
- Providing financial support for the construction of protective infrastructure (including protective forests), whereby the cantons give construction approvals along waterways and assess the needs for installing additional prevention measures;
- Providing financial support for the development of hazard maps;
- Providing financial support for the development and installation of hazard monitoring and early warning systems;
- Providing support for research and education; and,
- Consulting / advice.

In terms of reconstruction and rehabilitation, cantons are in charge of re-establishing and improving the status quo after a disaster event. Direct response functions include the establishment of a minimal level of safety and the re-servicing of important infrastructures. The following reconstruction phase aims at rebuilding buildings, taking due account of future damage potential, infrastructure and the functioning of the economy. Cantons are also asked to engage in systematic lessons-learned activities and to integrate them into long-term planning.

Federal Office for the Environment (FOEN)

The Federal Office for the Environment (FOEN) is part of the Federal Department of the Environment, Transport, Energy and Communications. FOEN's mission is to ensure the sustainable use of natural resources, including soil, water, air and forests. It is also charged with minimising natural hazards, reducing risks to the environment and human health from excessive pollution, conserving biodiversity and representing Switzerland in international environmental policy arenas. Four out of the FOEN's 14 divisions focus on natural hazards related topics, namely the forest, hazard prevention, hydrology and climate change adaptation units.

Based on the legal framework set out in the forestry law and the water engineering law, FOEN is responsible for water-related disasters such as floods and debris flows, landslides, rockfall and avalanches. Storms and forest fires as well as the coordination of the federal earthquake mitigation program also fall under FOEN's responsibility. Climate-related and meteorological hazards, such as heatwaves or cold waves lie in the responsibility of the Federal Office of Meteorology and Climatology.

FOEN is responsible for identifying and assessing risks that fall under its responsibilities. It thus plays a central role in guiding sub-national efforts in those processes and bringing results together at the national level.

FOEN, like other federal offices in Switzerland, is responsible for setting strategic priorities and for co-funding disaster risk reduction measures, but it is the cantons and municipalities that are responsible for actual disaster risk reduction measures. For example, FOEN is guiding efforts on assessing the impacts of climate change on natural hazards in Switzerland, such as a strategy that was issued in 2012 on national climate change adaptation (FOEN 2012a). Moreover, FOEN is providing advice and training for sub-national actors in charge of carrying our disaster risk reduction measures. Finally, FOEN is responsible for monitoring the implementation of disaster risk reduction measures by cantons, ensuring protective measures are in line with the water engineering and environmental laws.

Federal Office for Civil Protection (FOCP)

The Swiss Federal Office for Civil Protection (FOCP) is responsible for the protection of the population in cases of catastrophes and emergencies. Similar to other federal offices, FOCP is subject to the subsidiarity principle that guides Switzerland's administrative set-up. FOCP is responsible for risks that are of national importance (such as increased radioactivity, satellite crashes, dam bursts, epidemics or pandemics, epizootics, and armed conflicts), and for all others it is responsible for providing strategic guidance and working in collaboration with other sub-national levels. For example, FOCP supports the cantons to perform risk analysis and preparedness planning at the cantonal level. It does so by issuing guidelines for risk analysis and preparedness planning (FOCP, 2013).

FOCP is responsible for the national risk analysis for disasters and emergencies in Switzerland (FOCP, 2015b). In addition, it has a coordination function in the implementation of the national critical infrastructure protection strategy issued by the Federal Council in June 2012 (FOCP, 2012). It assists the sector-specific agencies and the operators assessing the risks and fostering resilience of the critical infrastructures. To

improve the resilience of critical infrastructures, FOCP encourages and provides guidance for critical infrastructure providers to conduct comprehensive risk analysis or to prepare for outages and failures in the system. FOCP does not provide any subsidies to critical infrastructure providers to implement such activities. As a consequence, it has been difficult to encourage operators to think beyond their individual asset protection to consider wider public safety in their disaster risk prevention and mitigation engagement. To overcome these challenges, FOCP has created an inventory on critical infrastructure objects that identifies highly critical infrastructures and monitors their vulnerabilities (FCOP, 2010).

Federal Office for Spatial Development (ARE)

The Federal Office for Spatial Development (ARE) plays a key role in providing national guidance for a hazard-informed spatial planning approach and determining fundamental rules. ARE views its core function as to develop spatial planning that not only keeps potential damages from natural disasters in the future limited, but aims at reducing it. Damage potential includes assets such as apartment buildings, individual houses or transport infrastructure in hazard-prone areas. The approach anchored in the legal frameworks (such as the water engineering law) also favours the use of spatial planning measures before investments in structural measures are undertaken. Finally, spatial planning also aims at maintaining existing flood retention zones as well as keeping areas unbuilt, where potential protective infrastructure could be built in the future.

ARE closely coordinates its activities with FOEN. In 2005, the two agencies jointly issued a guidance document on hazard-based spatial planning that primarily seeks to inform cantonal authorities in their responsibility to implement hazard-based land-use planning (ARE and FOEN, 2005).

Swiss Seismological Service (SED, Erdbebendienst)

The Swiss Seismological Service (SED) at the Swiss Federal Institute of Technology Zurich (ETHZ) is the federal agency responsible for monitoring earthquakes in Switzerland and its neighbouring countries and for assessing Switzerland's seismic hazard. When an earthquake happens, the SED informs the public, authorities, and the media about the earthquake's location, magnitude, and possible consequences. Earthquake monitoring became legally mandated in 1914, which led to the creation of the SED. In 2009, they released the Earthquake Catalogue of Switzerland (ECOS-09) online. The platform contains historical records of earthquakes from AD 250 until 2008. The records provide information regarding the magnitude, location, depth and other key statistics but not any socio-economic information.

Earthquakes are the hazard that is least present in the risk awareness among Swiss people (see risk communication section).

Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) with the Institute for Snow and Avalanche Research (SLF)

The SLF is an interdisciplinary research and service centre working in the fields of snow, avalanches, permafrost and mountain ecological systems. It forms part of the WSL

– the Swiss Federal Institute for Forest, Snow and Landscape Research. The SLF assesses the avalanche danger in the Swiss Alps and issues daily avalanche bulletins in the winter. The SLF's operational snow-hydrological service continuously analyses the distribution of snow water resources and assists the flood warning service of the FOEN. The work of the WSL has been key to advancing Switzerland's capacity in managing natural hazard based on progress in scientific research. Other institutes, such as the Institute of Geography in Bern, the Universities of Lausanne, Fribourg or Zurich or ETHZ have also contributed to advancing knowledge through natural hazard research.

Federal Office of Meteorology and Climatology (MeteoSwiss)

MeteoSwiss is the national weather and climate service for the Swiss public, for government, industry and science. With its public service, it ensures the basic supply of weather and climate information in Switzerland and thereby makes a substantial contribution to the well-being and the safety of the population. Surface observation systems, weather radars, satellites, radio sounding and other remote sensing instruments monitor the weather. Using the collected data, the weather services of *MeteoSwiss* generate forecasts and warn authorities and the public of imminent severe weather. Furthermore, these data are exploited by other teams of experts who analyse climate change and extreme weather events and develop scenarios for climate development in Switzerland

Federal Roads Office (FEDRO)

As part of the Federal Department of the Environment, Transport, Energy and Communications (DETEC), the Federal Roads Office (FEDRO) is charged with securing sustainable and safe mobility on the country's roads. Its main objective is to guarantee the functionality of Switzerland's motorways and main roads. As such, FEDRO plays an important role in guaranteeing that roads and motorways remain functional or become functional again during and after disasters.

Insurance industry

Switzerland has a mandatory insurance mechanism (for more details see section V). As a consequence, there are a number of insurance actors that play a key role in disaster risk prevention management:

Cantonal Public Insurance Companies for Buildings (Kantonale Gebäudeversicherungen)

The responsibility of the 19 cantonal public insurance companies for buildings (PIBs) is to provide building damage compensation in the event of a catastrophe, or so called elementary damage cover. They cover damages that arise from hail, avalanches, snow pressure, rockfalls, landslides, floods and storms. The cover is included in the fire insurance policy. PIBs have a monopoly status and work on a non-profit basis. In the seven cantons that do not have a PIB, a similar (nationally regulated) cover can be obtained from private insurance providers.

Private insurance companies

Private insurance companies provide the same insurance cover for buildings as the public insurance companies do. The private insurance industry not only covers buildings but also content and business interruption. The insurance cover is based on the respective law (*Aufsichtsverordnung*).

Apart from providing loss compensation, disaster risk prevention and loss mitigation is another role for private and public insurance companies, which have become increasingly important in the framework of an integrated risk management strategy in Switzerland. Insurance companies have become key actors in communicating about risks to private sector actors and citizens. They inform them about their responsibilities such as investments in self-protection, what options there are in investing in self-protection, and financially support such measures.

Other insurance actors include:

- Swiss Insurance Association (*Schweizerischer Versicherungsverband*, SVV): An umbrella organisation representing the private insurance industry, who in turn represents around 80 insurers and re-insurers. With the Swiss Natural Perils Pool (*Schweizerischer Elementarschaden-Pool*), the SVV has established a pooling of private insurance companies that allows better equalizing of risk associated with natural disasters.
- Association of Cantonal Fire Insurance Companies (VKF): An association representing the interests of public insurance companies for buildings and provides services for all prevention-related activities against fire and natural hazards at national and international levels.
- Inter-cantonal Re-insurance Association (*Interkantonaler Rückversicherungsverband*, IRV): A non-profit reinsurance association, which provides reinsurance for fire and natural hazards for public insurance companies for buildings.
- The Federal Financial Market Supervisory Authority (*Eidgenössische Finanzmarktaufsicht,* FINMA): The independent financial market regulator in Switzerland.

National coordinating bodies: PLANAT

The national platform for natural hazards, PLANAT, was founded in 1997 as part of the government structure to improve disaster risk prevention across Switzerland. It brings together representatives from the federal government, cantonal governments, research community, professional associations, private sector and insurance companies to work on three important areas of work to boost disaster risk reduction throughout Switzerland. Its first mission is to engage in strategic priorities in risk management. The second is to introduce and foster a culture of risk that drives the risk management agenda away from averting risks and towards an approach that integrates ecological, social and economic aspects in disaster risk prevention management. Third, PLANAT coordinates disaster risk prevention efforts in Switzerland to avoid duplication and increase synergies between the different actors' activities. It thereby acts as a platform of exchange that gathers and distributes good practices at the national and international level.

To fulfil its role on working on strategic priorities, PLANAT has been charged with developing a comprehensive and interlinked strategy to ensure comparable risk standards throughout Switzerland, with the aim to protect lives, livelihoods and material assets. It issued a major strategy in 2004 (PLANAT, 2004a) that paved the way for thinking of risk management in an integrated manner, also introducing the concept of a culture of risk. A number of consolidated reports on various disaster risk prevention topics followed the initial strategic framework. PLANAT's activities and results present a wealth of information today tailored to different risk management stakeholders across Switzerland.

Since its creation, PLANAT has made major contributions that have ensured that the management of risks remains present in political and public discussions. The composition of PLANAT with members from the different national and sub-national agencies, but also research and insurances as well as the private sector has been important to achieve their significance. To ensure PLANAT's effectiveness and usefulness in contributing to advancing disaster risk prevention management in Switzerland, a regular evaluation of its governance structure and activities could be useful. This could help orientate its activities and ensure relevance in the future as well. The governance structure, for now, is inclusive in terms of the different levels of government and the insurance industry. There could perhaps be room for reflecting upon opening all or some of its activities up to other actors as well, including for example civil society organisations.

National coordinating bodies: LAINAT

The Steering Committee Intervention in Natural Hazards (LAINAT), founded in 2008, brings all federal agencies (FOEN, FOCP, MeteoSuisse, WSL/SLF, ETHZ/SED) in charge of forecasting and warning about natural disasters together in one committee. LAINAT is in charge of informing and preparing for major disasters. It coordinates Federal Council resolutions on the "Optimisation of Warning and Alerting" and manages projects on hazard preparation, warning and altering. Its committee is set up by members from the above-mentioned federal agencies.

LAINAT created an online platform (www.gin.admin.ch) that informs and alerts the authorities about storms, floods, avalanches and earthquakes. This information is provided to the federal, cantonal and local level to facilitate response actions at the appropriate level. LAINAT also operates the website www.naturgefahren.ch, which is aimed at providing alerts regarding natural hazards to the general public (for more information on risk communication in Switzerland see section IV).

Cross-jurisdictional collaboration

Risks are rarely confined to municipal borders and may not halt at cantonal or country borders. Therefore, governance structures should ensure that disaster risk management operates at the adequate scales. Inter-communal collaboration is needed, especially for the development of joint spatial planning strategies for shared river areas and the development of compensation mechanisms between municipalities that pay for protection measures and others that may benefit or have additional costs. Collaboration methods include a range of partnerships, from establishing informal discussion fora and exchanging hazard information, to coordinating land-use planning activities or implementing joint protection measures.

The subsidiarity arrangements in Switzerland should ensure that disaster risk reduction measures are implemented on a functional level. To ensure coordination across administrative borders of cantons, cantonal authorities need to submit their proposals for protective infrastructure investments to the national level (FOEN) when the following occurs (BWG, 2001):

- Protective infrastructures are built along rivers that make up the border between different cantons;
- Protective infrastructure investments by one canton have a potential impact on other cantons;
- Protective infrastructure measures require an environmental performance assessment; or,
- Protective infrastructure coincides with a nationally protected area.

Based on the degree of collaboration across cantons, there are different coordination models, where either both (or several) or just one canton takes the lead in the implementation process. Accordingly, co-financing arrangements are made. In case of differences between the cantons, the federal government acts as a mediator (BWG, 2001).

When a measure is installed upstream, it needs to be proved that it does not worsen the situation further downstream.

The role of international collaboration

Switzerland participates in the Alpine Convention5, an international treaty between eight Alpine countries (Austria, France, Germany, Italy, Liechtenstein, Monaco, Slovenia and Switzerland) and the European Union. The treaty sets out to ensure the protection of the Alps and stresses the high value of sustainable development of the Alpine region. Since 2004, the Alpine Convention includes the Natural Hazards Platform of the Alpine Convention (PLANALP) that contributes to the development of joint approaches to disaster risk reduction and is mandated to implement subsequent measures, including flood (risk) management plans. Switzerland is engaged in the PLANALP through FOEN. Switzerland is also a member of several transboundary river commissions, such as the International Commission for the Protection of the Rhine (ICPR)6 that elaborate basin-level flood risk management plans. Switzerland is engaged in a cross border dialogue on the management of the Rhône that may develop into the creation of a coordinating body administered together with France. On the international level, Switzerland also cooperates with UNISDR, particularly in regards of the implementation of the overarching international frameworks. PLANAT also has a small working group on international affairs and a number of federal offices, including the FOEN, maintain collaborations with neighbouring and overseas countries. Moreover, scientific institutions maintain collaboration with institutions abroad.

Conclusion

This section showed that the governance set-up for disaster risk prevention in Switzerland much reflects its federal set-up, with strong powers devolved to the cantonal level. Switzerland is a good practice example for embracing a whole-of-society approach

to disaster risk management. It is considered that government efforts across all levels are only effective if private sector actors and individuals contribute their share in terms of risk adapted behaviour and self-protection investments. Insurance companies have played a key role in establishing a dialogue and informing private actors and citizens about their responsibilities in disaster risk prevention management.

The direct democratic tradition of Switzerland has also shaped disaster risk prevention efforts. Significant protective infrastructure investments are publicly scrutinised through often lengthy consultation processes. Although blockages can occur when only a minority opposes a plan, this process has by large ensured an efficient and effective provision of protective infrastructure that receives the support of its population. Coordination platforms such as PLANAT for strategic risk management issues and LAINAT for operational risk management issues ensure that a potentially fragmented, multi-layered system of actors is coordinated along key strategic priorities. Although these bodies have been effective in establishing a common vision and agenda for disaster risk reduction, their activities could be more regularly evaluated and their governance structures potentially opened up further.

This section's objective was to highlight who the main actors in charge of disaster risk prevention in Switzerland are. This is an important basis to subsequently assess specific disaster risk prevention activities, to ensure that roles and incentives are aligned to carry out disaster risk prevention tasks effectively.

Management of Structural and Non-Structural Disaster Risk Prevention and Mitigation Measures

Section Highlights

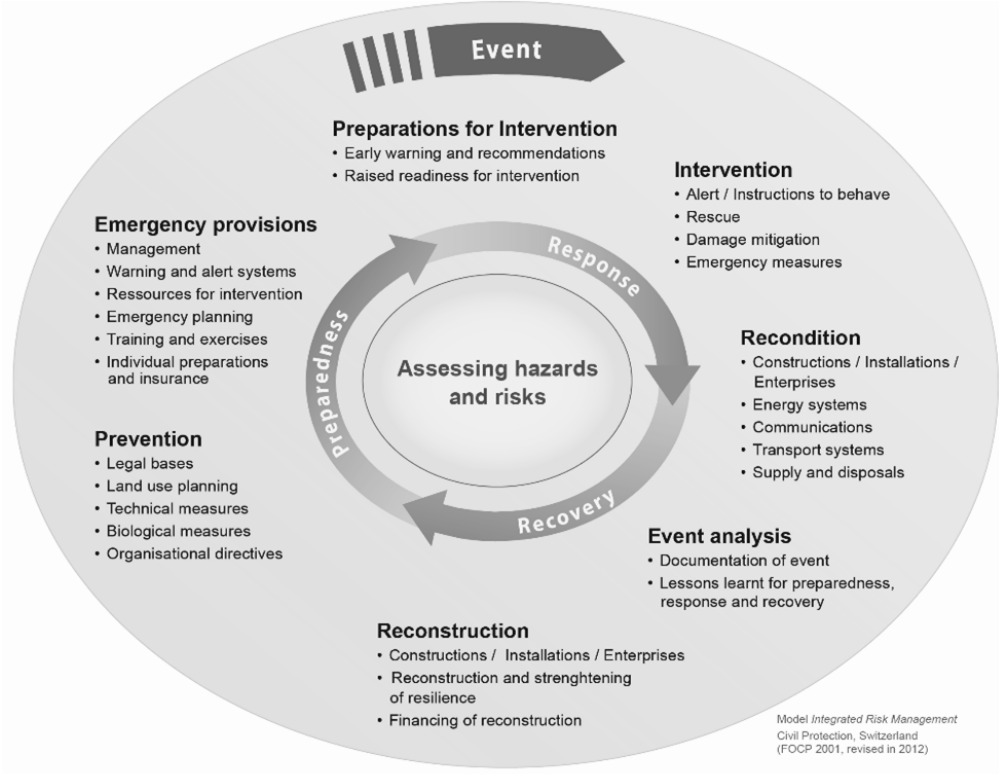
- A significant stock of protective infrastructure has been created over the past 100 or more years. Current constraints to funding its maintenance may create significant vulnerabilities and decrease the level of protection they were initially conceived for. Efforts are underway to creating a central database of infrastructure maintenance and rehabilitation needs. This should help prioritise maintenance efforts and inform cross-governmental financial planning
- There has been an important recognition about the need to boost funding for maintaining protective infrastructure. Although central re-allocation of disaster financing towards maintenance is welcome, it should ideally not undermine the long-term investment needs in new protective infrastructure.
- Most of the detailed information on hazard and risk assessments is collected at local and cantonal levels. To effectively manage disaster risk prevention priorities across levels of government, it is important to collate sub-national information centrally to enable the prioritisation of collective disaster risk reduction efforts.
- Switzerland's integration of hazard zone maps into land-use plans is in many ways a good practice example. Although this process has effectively avoided new investments in high-risk zones, it has failed to reduce damages in low-risk zones. A future focus should be on elaborating and finding ways to effectively monitor disaster risk reduction measures that apply to low-risk zones.

- Switzerland is a very good example for implementing a whole-of-society approach to disaster risk prevention management, for example by engaging insurance providers in translating and informing citizens and businesses about expected contributions to disaster risk prevention. Given the substantial investments that have been made in mobilising actors, an evaluation of these measures would be useful to ensure that investments are effective in reaching their objectives.

Introduction

Switzerland's experience with and management of natural disasters underwent significant changes in the past and developed into a modern, forward-looking and holistic risk management system that can serve as an example to many other countries. The Swiss approach to "integrated" risk management considers simultaneous and complementary measures for all phases of the disaster risk management cycle, ranging from preparedness and response measures to recovery (reconstruction) following a hazardous event (Figure 4.12).

Figure 4.12 The cycle of integrated risk management



Source: FOCP (2013), http://www.planat.ch/en/specialists/risk-management/what-has-to-be-done/

Experiences with natural disasters and their management date back centuries in Switzerland. Early disaster risk prevention management revolved around individually protecting one's assets. Community engagement and managing risks more collectively started growing in the 18th century, when cantons started to invest in public disaster risk

reduction measures. These measures were, at least in the beginning, implemented on the basis of achieving multiple goals and not just disaster risk reduction. For example, buying up (risk exposed) land was done to increase land for agricultural purposes, or the course of rivers was changed so as to decrease the risk of malaria. From the mid-19th century, the central government started to increasingly take on responsibilities to protect against natural hazards. In 1848, a constitutional law was developed to create the basis for investing in public (protective) infrastructure. Subsequently, federal laws were established for the forestry police (1876) and the water police (1877), based on which significant public investments were made for slope stabilisation and to construct protection measures against risks from torrents and rivers. This period was followed by a systematic focus on the protection against snow avalanches.

Most of the early disaster risk prevention measures were implemented as a reaction to the impacts suffered during major natural catastrophes, but recent developments in Switzerland have started to take a forward-looking, integrated approach to managing risks from natural disasters. A strong guiding principle has been developed since then. It prioritises soft measures that are nature-based (such as protective forests) over structural protective measures and creates a culture of risk, rather than a risk management that is reactive to the impacts of past disasters. A culture of risk can help in coping better with uncertainties and enables the uncovering of changes to the current risk profile (FOEN, 2016; BUWAL, BWG, BLW and ARE (2003).

The core of Switzerland's new *Leitbild* is that all measures used to deal with natural hazards are to be combined with one another, embracing the so-called integrated risk management approach, in a way that prevention measures effectively avoid hazards, reduce damage, while ensuring that society knows about and accepts residual or remaining risks.

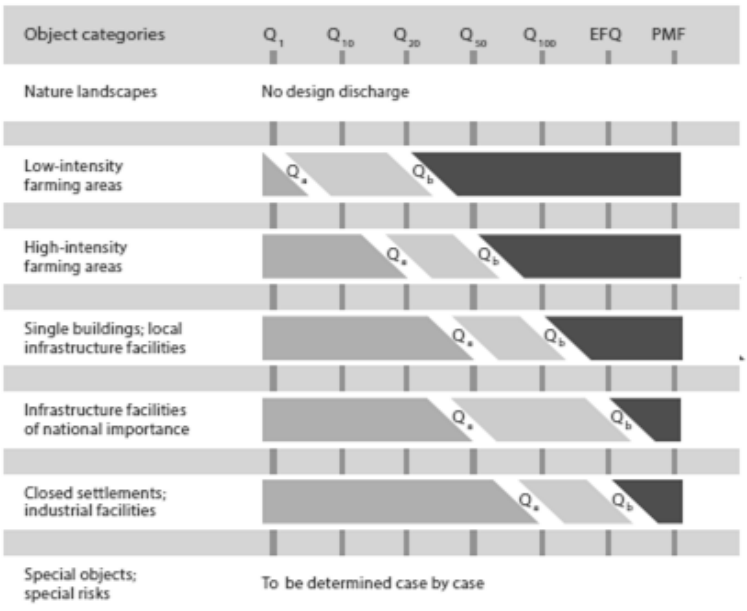
How are structural measures financed and decided upon?

Target protection levels

Since 2001, Swiss protection goals have been determined by the type of land-use as well as the value of material assets (BWG, 2001; PLANAT, 2014a). The higher the value of the assets, the higher is their target protection level. Figure 4.14 shows the different protection targets by types of land-use and illustrates the correlation between protection level and asset value. Settlement areas, for example, have to be protected against low-probability high-loss disaster events. Industrial plants have to be protected according to their economic and geographic (local, regional or national) significance. A similar distinction is made for determining protection levels for infrastructures. Agricultural land is thereby to be protected the least.

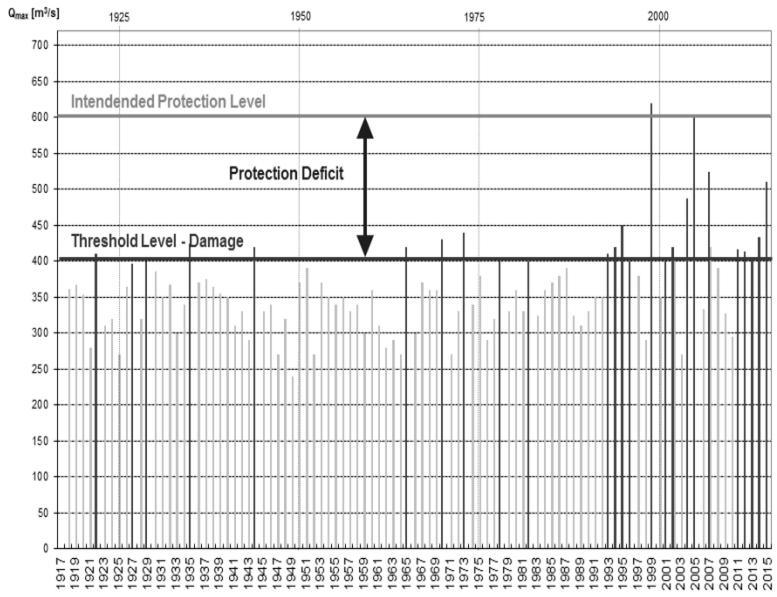
Protection targets have also been adapted based on the experience with past disaster events. For example, in the city of Bern, several recurrent floods of the Aare River, especially those of 1999 (CHF 25 million in damages) and those of 2005 (CHF 60 million in damages) led to an increase in the initial level of targeted protection (Figure 4.14).

Figure 4.13 Protection objectives for different land-use types



Source: Federal Department of the Environment, Transport, Energy, and Communications (DETEC) (2001), https://www.bafu.admin.ch/dam/bafu/en/.../flood_control_atriversandstreams.pdf
Note: Qa: damage limit; Qb: hazard limit; HQ1 – HQ100: flood return periods; EHQ: extreme flood event; PMF: probable maximum flood; red (right) bar: no protection; beige (middle) bar: limited protection; left (green) bar: complete protection.

Figure 4.14 Discharge rates of the Aare River and adapted target protection levels



Source: Presentation by Mobilab (Röthlisberger, V. and Künzler, M. (2016) during OECD mission

Implementation process for structural measures

In terms of implementing structural measures, it is the general responsibility of cantons and municipalities to protect citizens and assets from natural hazards. While the operational responsibility is in the hands of cantons, municipalities, infrastructure operators or other public or private authorities can be in charge of constructing protective measures (FOEN, 2016).

Although Switzerland's sub-national levels have the key responsibilities for natural hazard management, the national government finances a large share of structural protective measures. Structural measures implemented by the cantons are supported by the national level in form of four-year, canton-wide program agreements that receive global support as well as project-specific support for exceptionally large investments. The national agency in charge of coordinating these programs is FOEN, who, today, has a good understanding of sub-national finance needs for protective infrastructure investments. However, longer term estimations for funding demands are not available.

The national government finances around 35-45% of the total prevention investment costs. The cost share for cantons is about the same, and the remaining costs are either borne by whoever constructs the measure (e.g. a municipality) or by direct beneficiaries. The national average co-funding share is 35%, but can be as high as 45% if investment projects are especially ecologically friendly. The national level can co-finance structural measures, but is more restricted in compensating or co-financing organisational measures (such as buying up and freeing up land to create flood zones).

Before 2008, central level co-funding for disaster risk prevention also took the relative income level of cantons into consideration for their funding allocations. The equalisation has since been integrated in a national, budget-wide redistribution process so that income levels are no longer considered in the national level disaster risk prevention co-funding mechanisms across cantons; hence all cantons are treated the same way.

Protective measures have to be evaluated against their costs and benefits to receive co-financing by the national level. An instrument called "EconoMe" was developed by FOEN to aid decision makers in prioritising investments (Box 1). Cost-benefit considerations are important, but only part of the considerations when investments are evaluated. FOEN's objective is to plan protective measures in a holistic way, considering safety, social standards and environmental requirements, in addition to cost-benefit ratios. Each protective infrastructure investment should combine organisational and planning measures, restrictions for land-use and emergency planning measures. Finally, large protective infrastructure investments and the management of natural hazards in general, are subject to extensive public consultation processes.

Even though prioritisation tools and evaluations of project options for investing in protective infrastructure are available through national guidance, it is ultimately the cantons that will apply them. Since they receive a programmatic disaster risk reduction allocation from the central level, the question remains how well cantons are prioritising investments and to what extent rigorous evaluations of project objects are subject to sub-national political influence.

Box 4.1 The application of cost-benefit analysis in risk prevention projects

Switzerland has developed a standard Cost-Benefit-Analysis tool called "EconoMe" that supports the calculation of the effectiveness and evaluated the economic efficiency of a structural measure. The platform seeks to answer two central questions in the planning of protective measures against natural hazards:

1. How far can the risk be reduced (effectiveness)?
2. What is the relationship between the disaster risk reduction achieved and the costs of the measure (efficiency)?

The platform aids communal, cantonal and federal authorities in deciding which projects to support and how to subsequently prioritise those projects.

The EconoMe Platform has reached an advanced stage of development and is now used to calculate complex projects, variations of individual measures or combination of measures.

Source: FOEN (n.d.) "EconoMe 4.0" Federal Office for the Environment, Bern, http://www.econome.admin.ch/index.php

Operating and Maintaining Structural Measures

Protective measures implemented by infrastructure operators are often financed 100% by operators. Private insurance companies can co-finance protective measures as well.

The lead agency at the national level, FOEN, is responsible for monitoring that the implementation of structural measures across levels of governments follows the guidelines of the Federal Law for Water Engineering (WBG) and of the Federal Law of Forestry (WaG). Enforcement aids[7] published by FOEN provide additional technical guidance

The large stock of protective infrastructure that has been created over the past decades in Switzerland has to be adequately maintained if it is to provide the level of protection for which it was initially conceived. The same principle also applies to non-structural and “soft” measures, such as emergency plans that have to be practiced on a regular basis, or the maintenance of protection forests.

The water engineering law requires cantons to periodically assess hazard levels, which includes the protection levels of existing structural measures. Cantons have to finance the maintenance of these measures. Maintenance costs for the entire lifetime of the protective infrastructure are included in the cost evaluation conducted at the beginning of a protective measure project, but not necessarily in the actual project financing. In the Canton of Bern, for example, protective infrastructures are surveyed every five years. In the Canton of Bern, maintenance costs are shared between the canton (33%) and the communes (67%).

At present, few central or cantonal repository that provides information about each existing protective infrastructure, the level of maintenance, potential deficiencies or an assessment of the needs for rehabilitation works exist. In some cases, old protective structures fell short in providing the intended protection in part due to unforeseen overload situations. This makes it difficult to provide a clear overview of the functionality

of Switzerland's existing protective infrastructure. Existing protective infrastructure is or currently cannot be financially supported by the federal level. In the canton of Bern, such a repository (*Kataster-Geoinfrastruktur*) has already been created and is continuously being updated. Costs for maintaining protective infrastructures are expected to increase in light of the increasing age of many structures. As sub-national funding is expected to be too constraint to meet future maintenance needs, a recent discussion started about whether and how central level funding could be made available to support this task. If this situation prevails, vulnerabilities of current infrastructures could be set to rise in the near- and medium-term.

The Role of the Insurance Sector in Providing Protective Infrastructure

In an attempt to reduce future damage claims, the Public Insurance Companies for Buildings engage actively in supporting or co-financing public protective infrastructure. Insurance companies can provide for the full or partial share of local co-funding requirements for infrastructure investments.

How are non-structural measures managed?

Hazard assessment and mapping and land-use planning

Switzerland developed systematic hazard identification and assessment from early on. Records of hydro-meteorological hazard assessments can be found as early as 1863, where water and discharge levels started to be monitored regularly. Beginning in 1868, information on the channel geometry (cross sections) of the larger Swiss rivers started to be recorded systematically. Since 1979, daily weather reports have been made available. In 1914, an earthquake monitoring system was created. The Swiss Seismological Service (SED) was integrated into the Swiss Federal Institute of Technology (ETHZ) in 1957 (FOEN, 2016a).

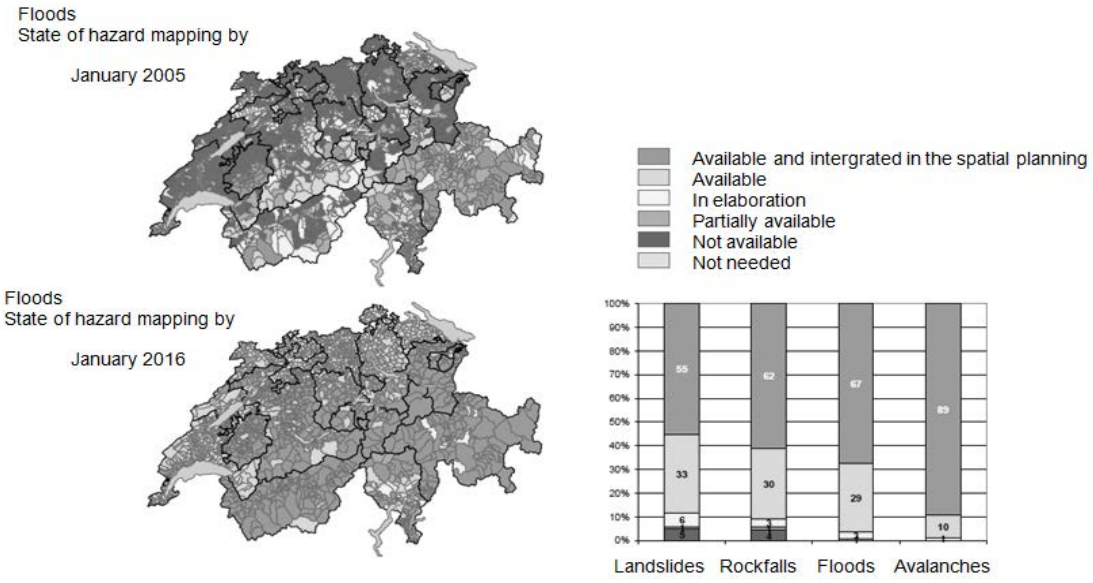
As a consequence of the catastrophic "avalanche winter" in 1950/51 that caused 98 fatalities, systematic collection and monitoring of snow data was established, which laid the ground work for today's avalanche forecast system (FOEN, 2016a). WSL is responsible for the avalanche forecasting service.

The SED produces seismic hazard maps for a reference soil at the national level. More than half of the cantons have established so called maps of seismic soil foundation classes or spectral seismic zoning studies to account for the influence of the local soil on the earthquake hazard. This information is taken into account for the design or verification of structures according to the building codes. It has limited implications on zoning plans and do not lead to construction bans (ARE and FOEN, 2005).

At the national level, guidelines to conduct hazard assessments are delivered by the Federal Office for the Environment (FOEN), except for earthquakes. The cantons are responsible for overseeing the development of hazard maps at the local level. The national level finances 50% of the risk assessment and hazard mapping conducted by sub-national levels

Hazard maps in Switzerland provide information about where settlement areas or transport routes are potentially impacted by floods, landslides, rock falls, avalanches, and, to the extent described above, also earthquakes. They provide information about the intensity of a potential hazard as well as the probability of it occurring. Outside of settlement areas, hazard information is provided but in a less detailed manner, which means they do not show information about potential probabilities or intensities of a disaster event[8]. 93% of required hazard maps are currently available (excluding earthquakes). Figure 4.15 shows how rapidly the gap in the availability of flood hazard maps has been closed since 2005.

Figure 4.15 Gaps in the availability of flood hazard maps



Source: Presentation by BAFU during OECD mission

Hazard maps have to be updated every 10-15 years or after major disaster events. At present, there is no national level aggregated risk map, although Switzerland is currently establishing a national portal that seeks to bring together cantonal geospatial hazard information in a harmonised way[9].

Hazard maps are usually divided into white, yellow/white, yellow, blue and red zones. Sometimes a brown zone is added that identifies land that has to undergo a special hazard assessment before constructions can be permitted.

Hazard maps and their underlying data are not only integrated and used in land-use planning (as will be described below), but they also inform the work of civil protection agencies. The Canton of Bern, for example, started to develop intervention maps that depict the level of threat divided into phases, choosing a colour key to represent and the necessary course of actions that are to be taken in the event of a natural hazard (yellow – observation and preparation / orange – intervention / red – escalation and evacuation). They include, for example, the installation of observers of the flood levels at critical points in municipalities, such as bridges (yellow phase).

Table 4.3 Hazard zones and regulations in Switzerland

Zone (colour)	Regulations
Red hazard zone (significant hazard threat: people in- and outside of buildings are in danger; buildings could be destroyed)	New constructions are forbidden; if land was initially earmarked for constructions it has to be changed to "non-constructible" surface; for changes to existing buildings, the risk is not to be increased; existing buildings must have evacuation plans;
Blue hazard zone (medium hazard threat: people inside buildings are not threatened, but outside they are; damages to buildings (but not full destructions) are possible)	As much as possible, there should be no new constructions; if land was initially earmarked for constructions it should as much as possible be changed to "non-constructible" surface; specific construction regulations apply to new buildings, such as the building of houses' fundaments has to be made of reinforced concrete; if changes are made to existing buildings in this zone, the risk shall not be increased;
Yellow hazard zone (low hazard threat: people are not threatened, but damages to the exterior of buildings and to its interior (if there is a flood) could occur)	Restrictions apply to sensitive buildings, where many people work or live or those that are difficult to evacuate (such as schools or hospitals, railway stations, retirement homes or camping grounds), but also services that are critical during emergency operations (such as fire stations, civil protection services) or buildings where low levels of hazard can cause significant impacts (such as water treatment facilities, switchboard stations, etc.);
Yellow/white hazard zone (residual risk zone: only if extreme events occur could damages occur)	Restrictions apply only to buildings that are important to maintain the level of security to citizens or those that can cause a significant damage potential;
White zone (no risk)	No restrictions.

Source: (AG NAGEF Bern, 2013)

Switzerland's energy sourcing from hydropower and nuclear power has created awareness among authorities about potential cascading impacts. In Switzerland, 56% of electricity is generated by hydropower and 39% from nuclear power. Switzerland shows awareness about the potential cascading impacts of natural hazards, such as earthquakes as a trigger to nuclear accidents and chemical plants, rock falls that can cause a flash flood in dams, oil catastrophes that are triggered by floods, transport accidents as a consequence of snow avalanches (PLANAT, 2004a).

Swiss authorities show increasing awareness that adapted protection against extreme floods with a very low return probability is needed. The EXAR project described in Box 2 above shows that there are research projects underway to better understand such future extreme risks. Switzerland's varied topography and climate make it subject to potentially significant changes in climatic conditions in the future, which will likely have impacts on both the intensity and frequency of future natural disasters. Expected effects could include more extreme weather events, more floods, glacier thawing and its potential impact on the tourism industry.

Box 4.2 EXAR: Evaluating extreme flood risks along the Aare and Rhine Rivers

In 2013 the Swiss Federal Offices for the Environment, Energy, Nuclear Safety Inspectorate as well as Civil Protection launched the EXAR project that aims at establishing a common baseline to evaluate the risk of extreme flood events for infrastructures built close to the rivers Aare and Rhine. In the beginning phase of the project, data were collected and methodologies developed that enable a standard evaluation of extreme flood events along those two rivers, including gauge height, flow velocity, morphological changes of the river and recurrence probabilities. Projections are based on estimated return periods of 10 000 years.

Based on the initial ground work that established the evidence base for modelling extreme flood events of the Aare, in 2016 the Federal Office for the Environment (FOEN) commissioned a study to understand and evaluate interaction scenarios or cascading impacts of extreme flood risk events. These include erosion, landslides, blockages through floating refuse and dyke breaches. The objective of this study is to understand vulnerabilities of infrastructures to extreme flood events.

Source: FOEN (2016d). Beurteilung der Gefährdung durch Extremhochwasser der Aare: Hauptstudie lanciert. [Evaluation of extreme flood hazards along the Aare: Main study launched], Federal Office for the Environment (FOEN), Switzerland, http://www.bafu.admin.ch/dokumentation/medieninformation/00962/index.html?lang=de&msg-id=60609

Integrating hazard assessments in land-use planning

The integration of hazard maps into land-use plans and land-use decisions has been exemplary in Switzerland. Hazard assessments have to be taken into account in land-use planning and mapping. The spatial planning law obliges cantons to identify areas that are potentially threatened by natural hazards. The hazard-informed land-use plan, of which an example is shown in Figure 4.16, constitutes a mandatory regulatory instrument. Local construction permits and construction regulations are adapted to the specific local hazard information. In terms of enforcement, actual application of regulatory prescriptions during construction processes has relied on self-declarations by property owners. Insurance providers can refuse damage compensations if such declarations were falsely made.

In terms of practical implementation, hazard zone maps are overlaid with existing settlement areas that have been identified in land-use plans, whereby potential new construction zones are also considered. The Federal Office for Spatial Planning (ARE), together with FOEN, have been providing trainings and information workshops for cantons and municipalities on how to implement the integration of hazard zones into land-use planning.

Not all communes have integrated their hazard and land-use plans yet, although the gap has been closing. In the Canton of Bern, for example, where the integration of hazard maps into land-use maps has been a mandatory requirement since 10 years, 245 of 352 municipalities have completed this process (AG NAGEF Bern, 2013). Some of the remaining gaps can be explained by planning cycles, for example land-use plans are renewed every eight years. The challenge will be to keep up with the underlying changes in risk patterns, in terms of both, the changes in the hazards, but also the evolution of hazard-exposed populations and assets.

Taking the integration of hazard zones into land-use planning yet a step further, Switzerland has elaborated a national spatial planning concept in 2012 (Schweizerischer Bundesrat, 2012). This was informed by the water protection law (*Gewässerschutzgesetz*) that, in 2011, started to prescribe a minimal space for rivers, which is expected to expand mostly into agricultural land (BUWAL, BWG, BLW and ARE, 2003). The concept, established jointly by the national government, cantonal and municipal authorities, recognises the limits of structural protection measures in disaster risk prevention management, especially given continuously evolving risk patterns. It therefore sets out the objective of creating space for the creation of flood retention zones, as an important complementary disaster risk prevention measure. This needs to be anchored strongly in present land-use decisions (FOEN, 2016).

Even though Switzerland has advanced significantly in integrating hazard information in land-use planning decisions, there are some significant challenges that prevail. The identification of red zones has been effective in prohibiting new building constructions. However, analyses have shown that more than 50% of the insured damage claims are actually being filed in areas that were determined as minor hazard (yellow) zones, where no specific land-use requirement was previously issued, but rather just information about the hazard level provided. This shows that efforts to reduce damages in high risk zones have been highly effective, but that protection or stricter regulations might have been overlooked in low hazard zones. Having recognised this as a challenge, ARE is currently elaborating measures that could be integrated in constructions taking place in low-hazard zones.

Building codes

Since land-use and construction permit decisions are a local responsibility in Switzerland, there are 26 different cantonal laws for building code regulations. Building codes are issued by private architect associations (such as the Swiss Engineers and Architects Association) and cantons adopt them in their legislations. Building code prescriptions for earthquake-proof design were introduced in 1970 that were subsequently made more stringent and more detailed in 1989 and 2003[10.] Critical infrastructure providers have also recognised the need to update their structures to make them resilient against the impacts of potential earthquakes.

Switzerland's building codes mostly correspond to Eurocode 8. Since 2004, there has been a specific pre-standard for the verification of existing buildings regarding earthquakes. This pre-standard will be published as a building code by the end of 2016 and will deal with the verification of the seismic safety of structures in general. The implementation of the seismic safety requirements has significantly improved since 2003 but is not yet systematic enough.

In terms of enforcement, much of the building code implementation relies on private responsibility. Although there are mechanisms, such as through the Public Insurance Companies for Buildings (PIBs), that require the implementation of building codes in order to obtain building insurance (VKF, 2005), public oversight of building code enforcement could be increased.

Resettlement

In general resettlements are a last resort measure and have been executed in only few cases. Examples are an industrial park in Preonzo that had to be relocated due to high risk of landslides and the ice hockey stadium in Ambri-Piotta, as its current location is at high risk of avalanches. The municipality of Weggis on the Lake Lucerne, where the local government decided to evacuate five properties and asked for the removal of the buildings, is the first example, where an owner filed a suit against the resettlement plans. Despite the complaint, both the cantonal court of appeal and the Swiss Federal Tribunal decided in line with the current code of practice of integrated natural hazard risk management and confirmed the evacuation and removal. It is not expected that resettlements will become a widely used disaster risk reduction measure in Switzerland, but they can be an alternative where other protection measures would cause disproportional costs (Heim and Denzler 2016).

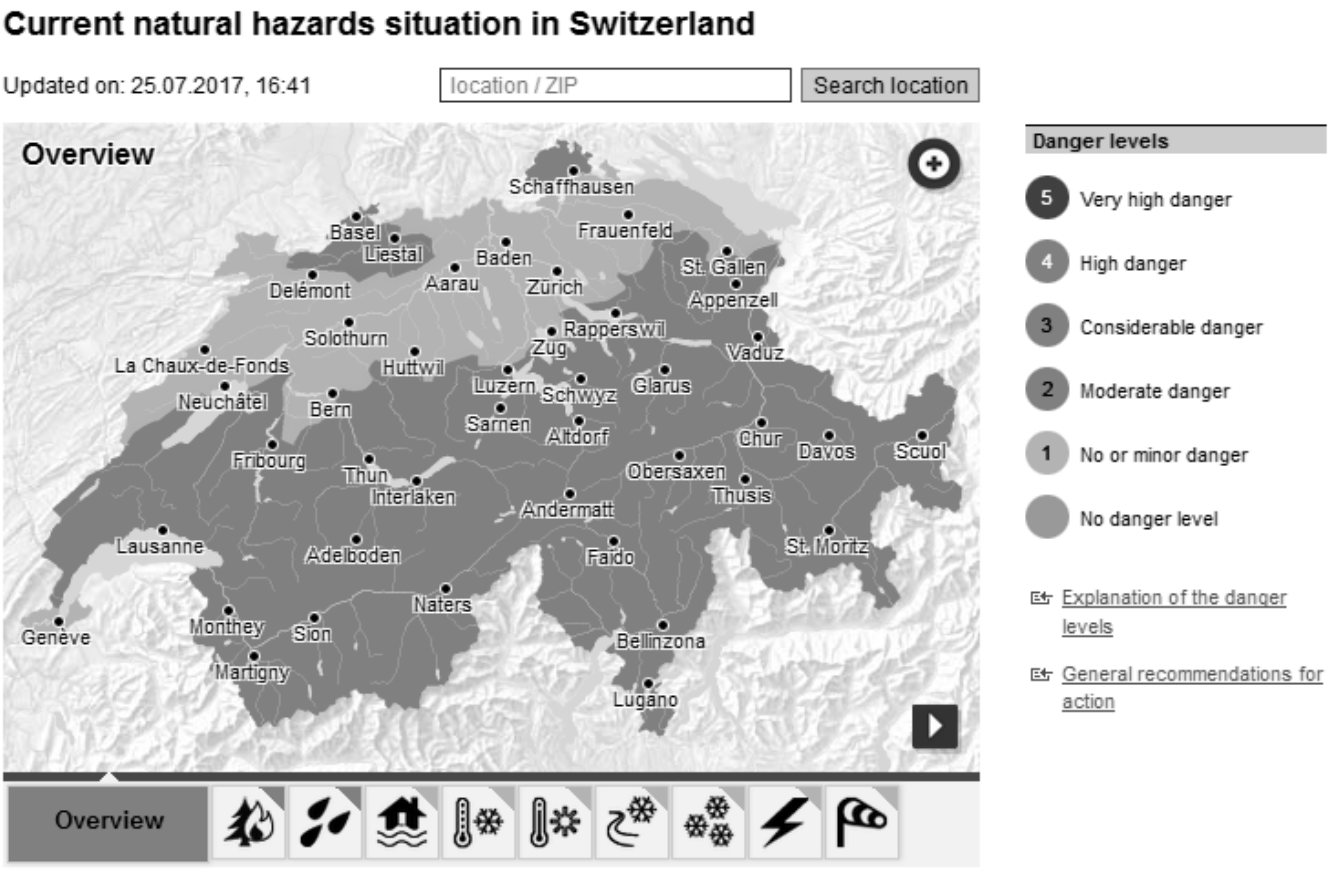
Risk Communication

The Swiss risk management agencies have recognised the importance of communicating about natural hazards, risks, uncertainty and the different actions that can be taken to reduce risks. The vision of Switzerland in that regard is that risk management can only be effective if responsible actors and citizens are aware of the risks and actively participate in reducing risks. The core objective of raising risk awareness is to inform citizens about relevant natural hazards and the risks they can pose to them. A key focus of their efforts is to not only raise awareness, but to keep awareness levels up through a continued dialogue on risk and by providing easily accessible information.

Insurance providers have played an important role in risk communication. One of their key objectives is to make sure citizens are informed about what they are expected to do in terms of disaster risk prevention. This includes knowledge about risk-adapted behaviour, but also self-protection measures in terms of construction designs and materials used. To support risk-adapted behaviours, some insurance providers have development automated text messages about bad weather warnings or imminent disasters. Insurance companies have gone a step further still, in providing financial support to boosting the capacity of fire brigades and rescue forces. Among the number of good risk communication practices, a few examples can be mentioned:

- A general information and alert service is provided through the www.natural-hazards.ch platform. Some cantons also have developed a cantonal version of a natural hazards platform, for example, the canton of Bern: www.naturgefahren.sites.be.ch/naturgefahren_sites/de/index.html. Through these platforms, the national government, cantons and municipalities inform and warn the general public about current risks from frosts, snow, heatwaves, floods, avalanches, as well as rain and thunderstorms, slippery roads, forest fires, winds and earthquakes (Figure 4.16). A 5-point scale (0 for no alert to 5 for high alert) is provided that can be broken down to specific places. This platform also provides general and detailed information about which protection measures can be done and what should be done when a disaster occurs. A strong emphasis is put on individual responsibility. A detailed list of situational measures before, during and immediately after the disaster is provided for each of the risks. Finally, the platform provides a full list of past warnings.

Figure 4.16 National hazard information platform

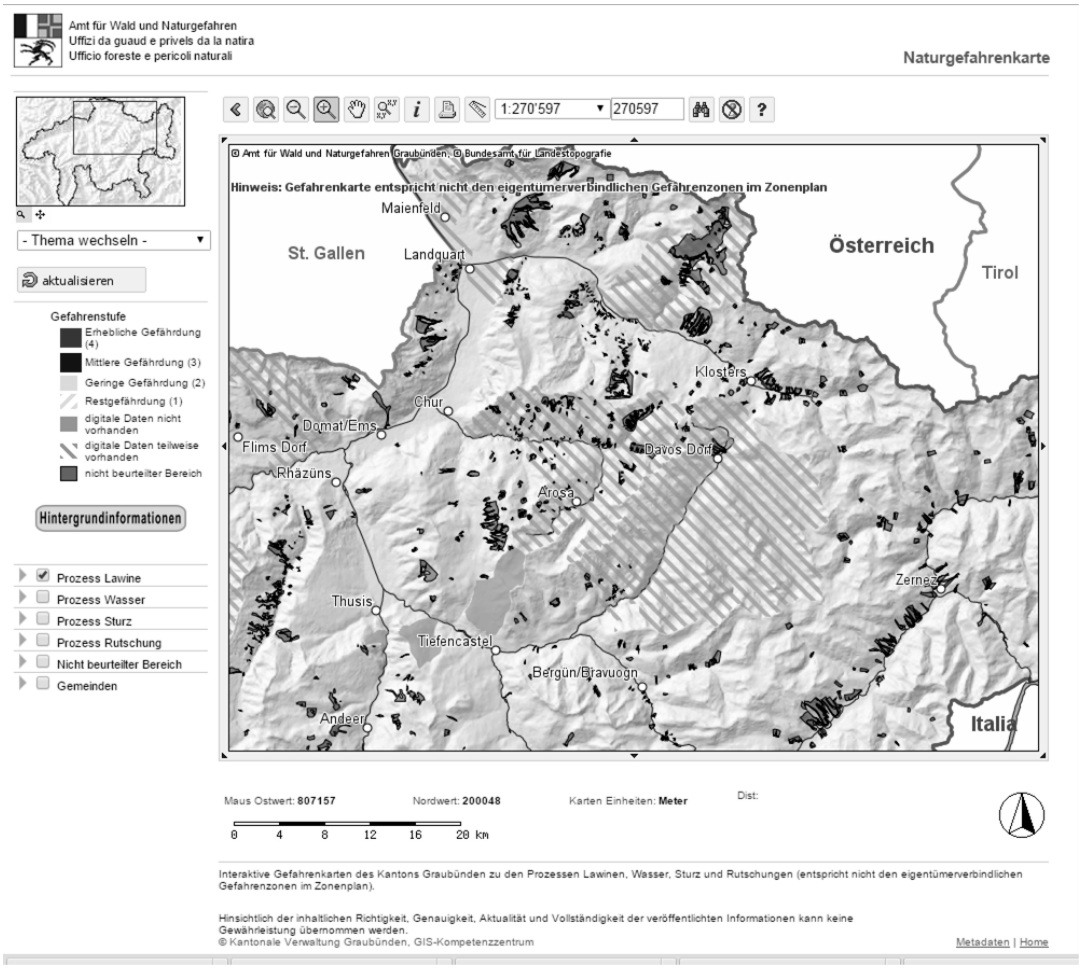


Source: http://www.natural-hazards.ch/home/current-natural-hazards.html

- To assess one's general (rather than immediate) hazard exposure, cantons provide detailed, address-based hazard maps, accessible online. An example is provided in Figure 4.18 for the Canton of Graubünden:

- PLANAT established an initiative entitled "*Risikodialog Naturgefahren*" (www.planat.ch/en/risikodialog/), through which it aims to raise risk awareness among public authorities, cross-governmental levels, citizens, owners and businesses, lay people but also among experts. The platform seeks to inform about what the public authorities can and should do and what other stakeholders can do to increase safety levels. Most importantly, it seeks to inform public authorities, including sub-national governments, about their responsibilities with regard to risk communication. The list of instruments stakeholders should use to inform the wider public about risks and to raise risk awareness include not only hazards and hazard maps, but all activities that public authorities engage in to manage risks (such as risk management strategies, risk-based land-use planning, and so on).

Figure 4.17 Cantonal hazard map for avalanches, water, rock falls and landslide risks (example of Graubünden)



Source: Office for Forest and Natural Hazards (2016), http://map.geo.gr.ch/naturgefahrenkarte/naturgefahrenkarte.phtml

- Switzerland makes sure to integrate risk communication in school curricula. The *Lehrplan 21*"[11] and the "*Plan d'études romand*"[12] seek to introduce children primary school to the origins of natural hazards. The topic is studied again in more depth during high school.

Despite the number of good practices there are some prevailing challenges in risk communication. First, communication regarding earthquake risk is comparatively low. Given that the potential impacts of earthquakes could be greater than those of any other natural hazard, it is important to boost earthquake risk communication efforts. Second, despite all the innovative risk communication approaches and tools, the biggest challenge that remains is to maintain risk awareness levels. Awareness is high after major disaster events, but decreases the more time has passed since then. Especially those citizens that have not personally experienced the impacts of a disaster are not sensitive to the topic. Since Switzerland's direct democratic culture is very much based on citizens' demands,

low awareness levels may also negatively impact the public resources allocated towards disaster risk prevention management.

Business continuity planning

Business continuity planning plays a crucial role in the context of critical infrastructure protection. Many enterprises in Switzerland have already established risk management systems including business continuity planning or security management. The primary focus of the application of these management systems usually lies in evaluating and managing the potential economic consequences of disasters for the enterprise. However, there is also a joint responsibility by the operator of the critical infrastructure and the public authority to take potential consequences of a critical infrastructure failure that are of importance for the general public into account. To support the critical infrastructure owners and operators in this endeavour, FOCP has issued a "Guideline for the Protection of Critical Infrastructure"[13] (FOCP 2012). It applies a holistic approach for dealing with relevant hazards and considers all conceivable disaster risk prevention and mitigation measures. In the risk assessment process, natural hazards as well as man-made hazards and technical failures are considered. A broad variety of measures are evaluated, ranging from organizational adjustments to structural-technical provisions. As absolute protection is not possible, nor feasible, proportionality of cost and benefits as well as a continued process of disaster risk prevention and mitigation measures are important. The more likely a risk occurs and the larger its potential damage to the community, the more extensive and comprehensive should the protective and mitigation measures be. The Guideline includes a monitoring and evaluation step in order to evaluate the success of the measures implemented. As the Guideline is non-binding and the FOCP is not a regulatory agency, critical infrastructure operators are not obliged to apply the Guideline. More and more economic associations and specific critical infrastructure owners are however interested in the application of the Guideline.

A whole-of-society approach to disaster risk prevention management

In advocating for a paradigm change, the Swiss risk management strategy of 2004 (PLANAT, 2004a), which is currently being revised, argued that if disaster risk prevention management is to be successful, it needs to be shared by all of society. This includes government, other public authorities, academia, insurers, practitioners as well as private sector actors and citizens.

Individual responsibility in the management of natural hazards has been a key priority in Switzerland. Individuals are expected to contribute to overall safety levels by investing in object-specific safety measures (such as the example provided in Figure 4.18) as well as adapt their behaviour to potential imminent disasters. The public insurance providers and the nation-wide public insurance association play a key role in informing about such individual measures. The insurance association, for example, issues detailed technical guidance notes for engineers, architects and construction companies on the different options to retrofit houses against the impacts of gravitational, climatological or tectonic hazards or to incorporate efficient techniques into new constructions (Egli, 2005).

Figure 4.18 Object-specific protection measure

Source: Jordi, Meier, Staub in Egli (2005), Building Protection against gravitational natural hazards, Guidelines, Union of the cantonal fire insurance agencies Note: adaptation of the house of the roof to its slope to make the avalanche run smoothly over it.

Lessons learned

Systematically assessing major natural disasters and learning lessons for improving risk management have been fostered as part of Switzerland's disaster risk management culture. Many reforms were implemented as a consequence of major disaster events. For example, after the devastating floods in 1987, a paradigm change was introduced recognising the limits of structural protection measures in providing protection against floods. Risk-informed land-use planning based on the development of hazard maps and the determination of different protection levels for different types of land-use came to the fore. Legal frameworks, including the water engineering law and the forestry law were revised and a new risk management strategy developed (BWG and BUWAL, 1991).

Assessing the risk management system after the 2005 floods underlined the importance of preparing for extreme events and reminded Swiss actors at all levels that uncertainties, driven by the potential impacts of climate change, require them to adjust the risk management system throughout its phases. The ex-post evaluations made apparent that many protective measures were built based on old technologies that did not take into account for example the compounding effects of bed loads in rivers. These evaluations identified a need to adapt old protective infrastructure to modern standards, which is a process that could take decades. The lessons learned also emphasised the importance and the need to collaborate and to improve the exchange of information during disaster events. Finally, an extensive analysis of risk awareness was undertaken, based on an historical analysis of media reports as well a survey across Switzerland. The results showed that memories of major disaster events fade quickly with time and those that perceive to be exposed to high levels of risks do not necessarily undertake individual prevention investments (Bezzola and Hegg (2007; 2008a +b).

Box 4.3 Mobiliar Lab for Natural Risks: A Private Public Partnership to bridge the Gap between Science and Application

The Mobiliar Lab was established in 2013 as a joint research initiative of the Swiss Mobiliar Insurance (providing the financial assistance for the initiative) and the Oeschger Centre for Climate Change Research at the University of Bern. The Mobiliar Insurance company has funded risk prevention investments by public authorities over the past 10 years, spending some CHF 32 million. The emphasis has been to provide seed funding to mostly poorer communities (usually around 50% of the community share of prevention measures) for building public protective infrastructure, focusing on river beds. To further support disaster risk reduction efforts, Mobiliar Lab was established to foster progress in high resolution spatial modelling of natural risks to inform the management and insurability of natural risks. The Mobiliar Lab focusses on risks from hail, storm, floods and mass movements in Switzerland.

Among the projects the Mobiliar Lab is working on are:

- Hazard maps of winter storms;
- Developing radar-based hail hazard maps to improve hail warning systems;
- Development of a spatial insurance claim database of Switzerland;
- Development of a country-wide spatial database of buildings and content exposed to and hit by floods;
- Evaluation of 71 flood protection projects to identify improvements in the planning and implementation process and to evaluate the role of insurance involvement; and,
- Beside research, a major goal of the Lab is to bring research findings into practice to improve natural risk management and prevention efforts.

Source: Universität Bern (2016). Mobiliar Lab for Natural Risks University of Bern, Switzerland, http://www.mobiliarlab.unibe.ch/; Presentation by Röthlisberger, V. and Künzler, M (2016)) during OECD mission

Conclusion

Protective infrastructure investments have been a core part of Switzerland's disaster risk prevention measures. A large stock of infrastructure has been created since the early 19th century. Aging infrastructure, much of which has been built in reaction to events rather than in a forward-looking manner, along with sub-national maintenance budget constraints, may contribute to exacerbating vulnerabilities in current infrastructure. Efforts are underway to build a central database to contain information on the level of maintenance and rehabilitation needs of the current infrastructure. This should help prioritise maintenance investments and inform budgeting for term maintenance finance needs in the medium term. Although these developments are encouraging, it is important that maintenance funding is not being made available at the expense of future infrastructure investment needs. When deciding on future infrastructure investments, a forward-looking perspective that takes long-term risk evolution into account is crucial (Suter et al, 2016). This should receive further attention at the local level, but is equally important for cantonal and federal level decisions.

In the past decade, the gaps of locally available hazard and risk assessments as well as their integration into land-use plans for most natural hazards have been closing for new construction projects. Owing to high construction activities prior to the availability of hazard maps, the gaps are closing slower in the case of existing buildings. Efforts to provide information on the effect of local soil on earthquake risks are underway that will

inform changes in the development of building codes in different earthquake zones. To improve strategic national level planning, it would be desirable to speed up the compilation and harmonisation of national level risk maps. Although factors that might alter risk patterns in the medium term, such as climate change, have started to being addressed in the risk mapping process, this could perhaps also benefit from being implemented more rapidly so as to allow other risk management actions to adjust swiftly.

Risk communication has been a good example that shows the commitment of Switzerland to a whole-of-society approach to disaster risk prevention management. The role of insurance providers and individual citizens and businesses in reducing risks through behavioural measures and self-protection investments is significant. An evaluation of the actual take-up of disaster risk reduction measures across societal actors could in the future inform activities that aim at increasing whole-of-society contributions to disaster risk reduction.

Risk Management Financing

Section Highlights

- Studies were conducted in the past to collect information about the total value of investments in disaster risk prevention across levels of government and non-governmental actors in Switzerland. This has not been done on a regular and systematic basis. To ensure that public spending in a fragmented context, such as in Switzerland, is effective, it is important to collect figures on investment volumes by all levels of government, and ideally non-governmental actors, on a more regular basis.

- Fluctuations in disaster risk prevention funding across levels of government that are caused by general economic conditions or by the occurrence of major disasters make medium-term planning difficult. In a context of increasing funding needs for maintaining and rehabilitating existing infrastructures, financial planning uncertainty could increase vulnerabilities in aging protective infrastructure.

- The quasi-mandatory insurance system has enabled an extremely high level of household and business resilience against the impacts of disasters. Discussions have been ongoing for preparing the conditions for introducing earthquake risks. Even though insurance companies are actively engaged in fostering risk-prevention measures among their clients, it is important to evaluate the effectiveness of these activities, given the significant disincentivising effects mandatory insurance schemes can have.

Public expenditure for disaster risk prevention and mitigation

Cantons and the federal state share the responsibility for protection measures. Public funding for disaster risk prevention is dependent on financial planning at the federal level, the needs of the cantons and the occurrence of natural disasters. Since funding for disaster risk prevention is provided by several actors and levels of government, the picture of the total investments in natural disaster risk prevention across Switzerland is rather fragmented.

The total allocation for disaster risk prevention at the national level is determined by the needs for investments in disaster risk prevention projects by the cantons as well as on the basis of the 4-year programmatic allocations. There is no longer term planning of financial needs for disaster risk prevention. In recent years, cantonal level funding for disaster risk prevention has reduced, which reduces demand for complementary national funding.

There is no systematic and regular overview of the total budget allocation for disaster risk prevention in Switzerland. PLANAT conducted a study in 2007 where it collected different expenditure figures by different levels of government and non-governmental actors. This exercise revealed that, in 2007, a total of CHF 2.9 billion was spent annually on natural hazard protection in Switzerland. The insurance sector, private companies and households provided CHF 1.7 billion of this amount. Of the remaining CHF 1.2 billion, the national authorities contributed CHF 462 million, the cantons CHF 321 million and the municipalities CHF 393 million, which corresponded to approximately 2% of the federal budget (PLANAT 2014). 30% of the total investments were used for flood risk prevention (PLANAT, 2014).

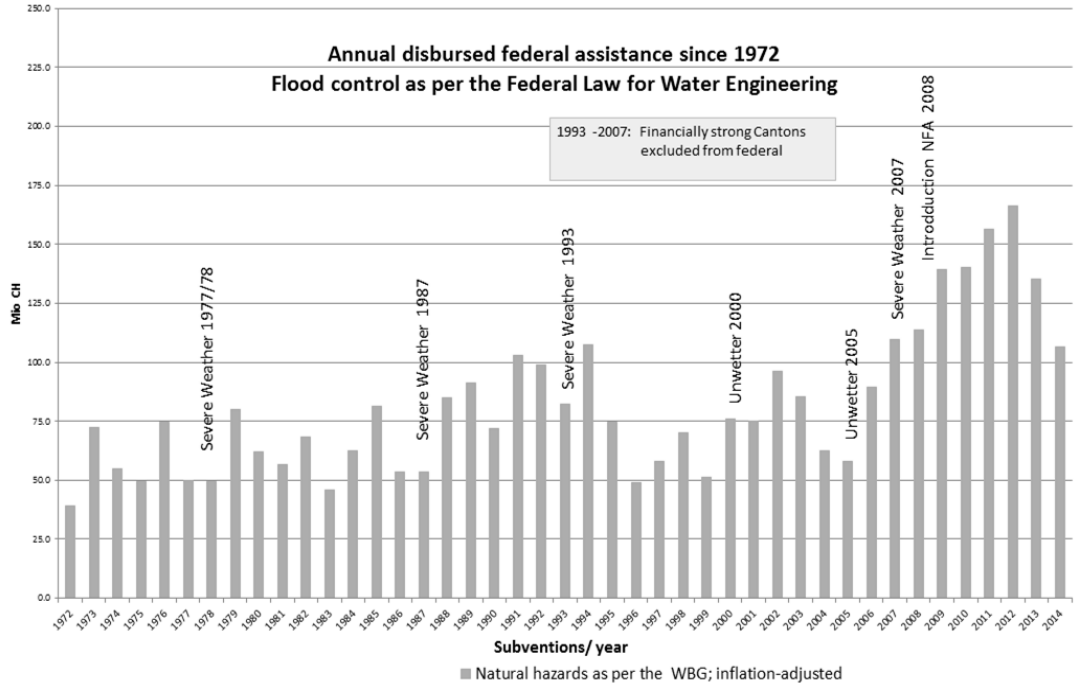
For 2015, PLANAT conducted a survey of the public funding across levels of government for disaster risk prevention management. It found that, of the total annual amount for risk management, CHF 1.3 billion was spent on prevention, CHF 392 million on emergency interventions and CHF 1.1 billion on rehabilitation.

Figures 4.20 and 4.21 show the evolution of national-level expenditures for floods and other natural hazards. The graphs show that budgets are strongly reactive to the occurrence of significant disaster events. For example, the budget saw a significant increase in terms of funding after the floods in 2005. Before the event, FOEN was not in a position to finance all disaster risk prevention investment requests which is why rigorous application of Cost-Benefit Analysis was necessary to determine priorities. Since the 2005 floods, this process has been reversed and the FOEN has more funding available than requests received. It is expected that in the next years, funding will again become scarce, given an increase in protective infrastructure investments and the potential central level funding requirement for maintenance costs (discussed in section IV).

In combination with the absent systematic and regular overview of the total budget allocation for disaster risk prevention, the federal budget developments indicate that Switzerland's disaster risk prevention system might be in a less proactive position than its responsible actors might like it to be. Variations in the investment budgets for protective infrastructure seem to come from federal level contributions, but also from sub-national level contributions (Figure 4.22).

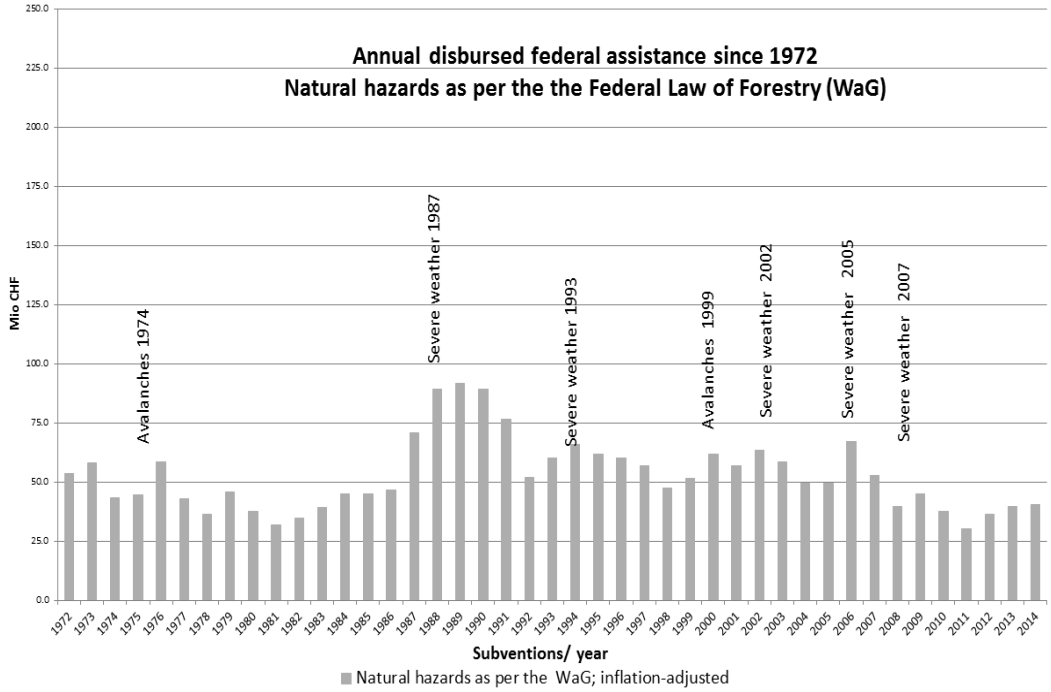
With regard to flood, landslide, rockfalls and avalanche risk management, the total amount of annual expenditure equals the total estimated average of damages stemming from these hazard sources, which corresponds to about CHF 320 million annually.

Figure 4.19 Expenditure for flood risk management at national level, 1972-2014



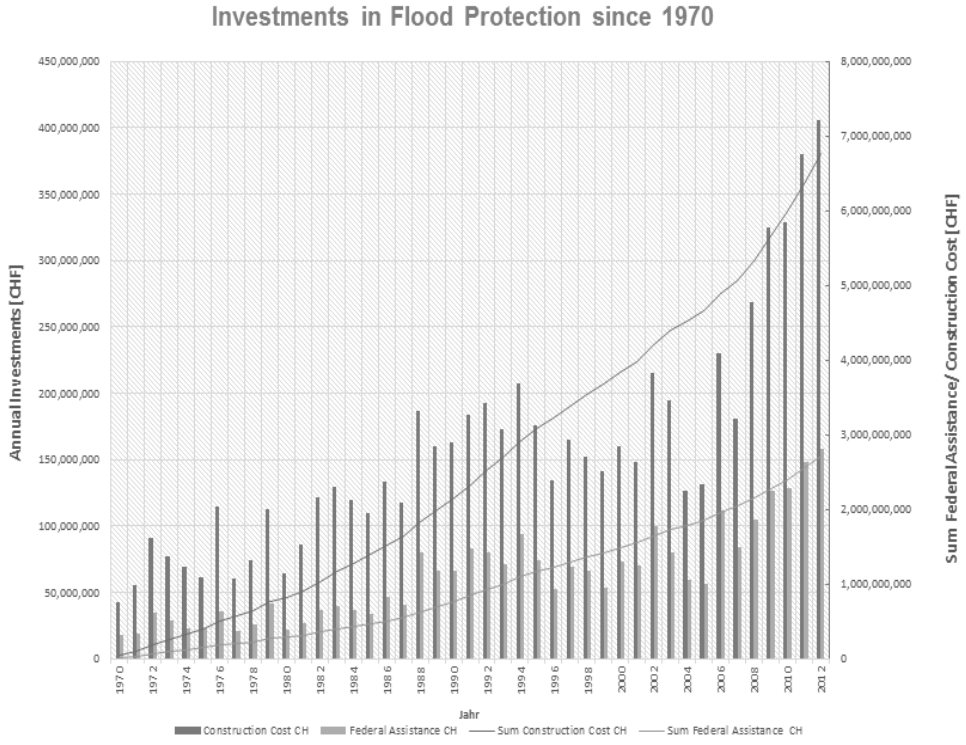
Source: Federal Statistical Office (2016), https://www.bfs.admin.ch/bfs/en/home/statistics.html

Figure 4.20 Expenditure for landslide, rock falls and avalanche risk management at national level, 1972-2014



Source: Federal Statistical Office (2016), https://www.bfs.admin.ch/bfs/en/home/statistics.html

Figure 4.21 Investments in Flood Protection, 1970-2012 (Federal contributions versus total investments)



Source: Presentation of PLANAT during OECD mission; FOEN (2016a)

As mentioned in the previous section, central-level funding for structural protective measures is allocated to cantons on a programmatic, 4-years basis. This excludes big investment projects that cost above CHF 5 million, for which separate funding is provided. The basis for programmatic allocation decisions are – among others – the damage potential determined on the basis of the Aquaprotect flood zones[14] and the needs arising from the planning at sub-national level.

Natural Hazard Insurance

Switzerland has nationwide natural hazard insurance for buildings and content, which is linked to fire insurance. Cover is provided for damages arising from floods, storms, hail, avalanches, snow pressure and rockfall or landslides.

In 19 cantons, building insurance is provided by cantonal monopoly insurers (PIBs), which are public, non-profit companies. In the remaining seven cantons (Geneva, Uri, Schwyz, Ticino, Appenzell Innerrhoden, Valais and Obwalden) natural hazard insurance for buildings is provided by private insurance companies. Insurance must be provided for all buildings in a canton, regardless of their risk exposure, but premium rates can be adjusted, if they face high risk exposure (e.g. in one of the cantons: glasshouses and buildings with an extraordinarily bad loss experience may face premium rates of 40 per mill instead of 0.4 per mill of the sum insured) (OECD, 2016). The PIBs cover 80% of the insured assets.

Coverage for building insurance is similar across the country and premium tariffs are affordable. In all but four cantons (Geneva, Tessin, Valais and Appenzell Innerrhoden) building insurance is mandatory. The total value of building damages has to be compensated. Deductibles can vary between 10% and 15% of damage, with a minimum of CHF 200 and a maximum of CHF 2000).

Content insurance against natural hazards is provided by private insurance companies across the country, except for Vaud and Nidwalden where this is provided by the PIBs. The extent of the content cover is regulated and is similar across the country. In contrast to building insurance, content insurance is limited by policyholder and by event. Content insurance is voluntary throughout the country, except for Vaud and Nidwalden. The Swiss Insurance Association estimates that 90% of all households have household insurance, which means that property owners very likely have building insurance and renters have household insurance. Many businesses have natural hazard insurance for their inventory as well as for business interruption. The PIBs formed a non-profit, inter-cantonal reinsurance association (*Interkantonaler Rückversicherungsverband,* IRV) in 1910. The IRV provides reinsurance for 18 of 19 PIBs for fire and natural hazards (the canton of Bern left the association in 2014). Losses accumulated over one year are added together for calculating reinsurance pay-outs. In its own interest, the IRV is strongly engaged in loss prevention as well. The PIBs founded their own prevention fund in 2004 (IRV, 2016) to support those activities in the field of long-term risk research projects. In addition, private insurance companies formed the Swiss Natural Perils Pool (*Schweizerischer Elementarschaden-Pool*) to better equalize the risk associated with natural disasters and to enable affordable flat premiums for all policy holders[15].

Finally, Switzerland created the "*fondssuisse",* a fund for natural hazard damages that cannot be insured, formerly called the Swiss elementary damage fund (*Schweizerischer Elementarschädenfonds*)[16]. Created in 1901, it was founded by the Swiss society for public utility (*Schweizerische Gemeinnützige Gesellschaft,* SGG). It is funded by taxes and insurance premiums. The fund provides support for damages from natural hazards that were not predictable or insurable. The payments from the fund are voluntary and no one can claim a right for pay-out. The pay-outs are dependent on the financial situation of the persons suffering the damage (deductions are made for persons having an income above CHF 100,000). 60% of the damages are usually compensated, which often gets complemented by cantonal funds.

Switzerland's insurance system is strongly rooted in solidarity and has in the past demonstrated that its objective of achieving resilience in citizens and businesses against natural disasters has been efficiently achieved. Swiss insurance authorities are conscious of the potential moral hazard risk that arises when insured clients rely on insurance pay-outs instead of investing in disaster risk reduction efforts prior to a disaster. Therefore, insurance companies have been actively engaged in not only informing citizens about their individual responsibility (in terms of adapting their behaviour in the event of a disaster, and in terms of investing in self-protection measures), but enforcing it when providing eventual pay-outs for damage compensation. For example, if expected disaster risk reduction measures were not installed, the insurance company would decrease the pay-out amounts. It is important to systematically evaluate the effectiveness of these measures to understand whether moral hazard is being successfully avoided.

Mandatory earthquake insurance currently does not exist, except for the canton of Zurich, although private insurers supply earthquake covers for interested clients. Cover is provided by the PIBs in 17 out of 26 cantons if an intensity of VII on the European Macro-seismic Scale or higher is reached. As earthquake is an excluded peril, the cover granted by the PIB is technically neither insurance nor an indemnification, but rather a voluntary contribution. This is done through the Swiss Pool for Earthquake coverage (*Schweizerischer Pool für Erdbebendeckung*), managed by the IRV. No additional premium is paid by policy holders. The Pool has a maximum of CHF 2 billion of pay out, plus another 2 billion in case of further earthquakes following the first. If losses exceed this amount, percent deductions will be applied to all claims. The deductible amounts to 10% of the insured value, with a minimum of CHF 50 000.

A proposal for nationwide mandatory earthquake insurance with a capacity of CHF 20 billon has been worked out by the federal government (under the lead of the Federal Department of Finance, EFD) and the insurance industry between 2013 and 2014. This proposal could be implemented in two ways, either through an agreement between all cantonal governments (concordat) or through a constitutional modification. To date, neither solution could be implemented as 6 of the 26 cantons are against the introduction of a mandatory insurance and the majority of the parliament is against a constitutional modification. Further discussions are currently being held to try to convince all cantonal governments to adhere to the idea of a concordat. In the meantime, it has been recognised that an organisation should be created to assess the damage after an event and distribute the financial aids to the building owners. Such an organisation would be needed with or without a mandatory insurance. Work in this direction involving FOEN and the insurance industry started in 2016.

Conclusion

Switzerland has invested significant amounts of resources in protecting their citizens and the economy against the negative impacts of natural disasters. Guided by solidarity, all levels of government as well as non-governmental actors have contributed to reducing risks stemming from natural disasters. However, in despite of these contributions – or perhaps because of them – there exists an incomplete picture of the financial contributions by the different actors. Without an understanding of the total regular contributions by all actors, the steering of disaster risk prevention management towards priority projects is difficult and may render protective infrastructure investments less effective. It is important to compile this information across cantons and different non-governmental actors to better target and prioritise spending, to make sure that expenditures by different actors are not undermining each other and to provide more transparency and accountability.

A clearer picture of the total available resources is even more important in the future. With changing climatic conditions and other risk factors evolving in the future, Swiss authorities expect investment needs for protective measures will increase. At the same time, it is becoming increasingly clear that maintenance and rehabilitation needs for the large existing stock of aging infrastructure are set to increase too. To meet future disaster risk prevention investment needs, it is important to engage in longer-term financial needs

assessments and financial planning to avoid an increase in vulnerability to citizens and assets from the impacts of disasters.

Finally, Switzerland is a best practice example in terms of achieving near-universal coverage against natural disasters through mandatory insurance. Swiss citizens and businesses enjoy affordable access to full coverage of eventual natural disaster damages, except for earthquake risks are currently under debate for inclusion. Insurance companies and Swiss authorities are very aware of the potential moral hazard risk that arises if insured households or businesses refrain from investing in self-protection measures to reduce eventual damages. In light of this, active campaigns have been launched to inform clients of their disaster risk reduction obligations. Insurance companies may also reduce or refuse damage compensation payments in case expected disaster risk reduction measures were not implemented. It is important to evaluate the effectiveness of past and ongoing campaigns to reduce the risk of moral hazard so as to improve the efficiency of natural disaster insurance in the future.

Assessment and Recommendations

Switzerland is a landlocked country, geographically marked by the Alps in the South and the Swiss Plateau and the Jura in the Northwest, where the majority of the population is concentrated. The topographical differences between the three geographical areas and regional climatic variations leave the country exposed to a variety of different hazards, ranging from gravitational and water-related hazards over meteorological hazards to tectonic hazards.

Over the last seventy years, Switzerland's population almost doubled and housing and infrastructure grew accordingly. The increase in building stock and land used for infrastructure and industrial activities went hand in hand with an increase in infrastructure and building stock at risk, with for example 25% of assets and 22% of the population as well as 30% of jobs located in flood risk areas.

Switzerland has recognised the need to address the risk it faces and has embraced a modern and forward-looking whole-of-society approach to managing disaster risk reduction. Different levels of government, as well as insurance companies, private sector actors and citizens share the responsibility for disaster risk reduction management. Swiss disaster risk management has a long tradition, with first cantonal investments dating back to the 18th century and the first legal basis passed in 1848. In contrast to the original measures, Switzerland today prioritises nature-based protective measures and a culture of risk in society, taking a forward-looking rather than a reactive approach to managing disaster risks.

Identification and monitoring of current and future risks

Switzerland has taken a forward-looking approach to managing the risks it faces and increasingly puts natural disasters in perspective with other risks, including pandemics and nuclear accidents. Systematically assessing major natural disasters and learning lessons for improving risk management has been fostered as part of Switzerland's disaster risk management culture. As a consequence the level of awareness and alertness about

future changes to disaster risk patterns, both from a socio-economic development perspective and a climate risk perspective, is high. The natural hazard management strategy highlights factors that may change future risk exposure, addresses expected increases in vulnerability linked to economic interconnectivity and takes changes in climate and weather into account. Works are underway to understand the underlying socioeconomic and climatic patterns more closely and to integrate potential implications into local risk management planning and implementation. Well-established channels of risk communication at the national and cantonal level and by insurance providers help informing citizens and authorities about the risks they face.

Switzerland has achieved a remarkable level in terms of comprehensiveness and quality in recording losses caused by disaster events. Since the 1970s social and economic disaster losses from storms, floods, debris flows, landslides and (since 2002) rockfalls are systematically registered in a central data repository administered by the Federal Institute for Forest, Snow and Landscape Research (WSL). Data currently is obtained from three main sources: newspaper articles, official data from cantons and data shared by the insurance industry. While it is a good practice to bring different actors on board of the data collection efforts, data may not always be equally complete or of the same quality. To address this, it could be useful to establish a more systematic approach to data collection across all cantons, including those where the natural hazard insurance is not organised by public insurance companies. It equally could be useful to expand the current database to also include damage caused by hazards currently not accounted for, such as metrological hazards. As indirect economic losses account for a significant share of total disaster losses, collecting data on them could provide a useful addition to the data already collected by the WSL.

Legal and institutional frameworks for disaster risk prevention management

Owing to Switzerland's long experience in addressing disaster risks, capacity for risk management is high. The strong legal and institutional risk management framework and the country's whole-of-society approach illustrate this.

The national level takes a steering role in defining the overall direction of risk management, underpinned by various sector-specific federal legal instruments and anchored in the Swiss constitution. At the federal level, the task of addressing different aspects of disaster risk reduction is shared between a range of actors, with FOEN in the lead of storm-, forest fire,- and water-related hazards, MeteoSwiss responsible for climate-related and meteorological hazards and FOCP in charge of the other risks of national importance. As a federal state, the responsibility for risk management is not only shared between various ministries, but also across levels of government. Cantons take the lead in enforcing national policies and supporting their implementation, while local municipalities actually turn policies into action.

Owing to the nature of Switzerland's federal system, local and cantonal responsibilities are not always the same, allowing for possible reinforcements of the system through a more streamlined division of responsibilities. As risks rarely take municipal or cantonal borders into account and may even cross national borders, governance structures also need to ensure that disaster risk management operates at the

adequate scales. Inter-communal collaboration is crucial and should be further encouraged and streamlined across the country, especially as regards developing joint spatial planning strategies for shared river areas and for sharing the cost of protection measures across all communities that may benefit from the investment. International cooperation with neighbouring communities and stakeholders across Switzerland's borders, for example in flood risk management along transboundary rivers should be part of these efforts.

By creating national coordination platforms such as PLANAT for strategic risk management issues and LAINAT for operational risk management issues Switzerland has addressed some of the potential shortcomings of a fragmented governance system. While PLANAT is a key example for the Swiss whole-of-society approach to risk management, LAINAT is a platform on the federal level, bridging gaps between the various government actors involved in operational risk management. Although these bodies have been effective in establishing a common vision and agenda for disaster risk reduction, their activities could be more regularly evaluated and their governance structures potentially opened up further and strengthened further.

Switzerland is a good practice example for embracing a whole-of-society approach to disaster risk management. It is recognised that government efforts cannot be effective if private sector actors and individuals do not contribute their share in terms of risk adapted behaviour and self-protection investments. Insurance companies have played a key role in establishing a dialogue and informing private actors and citizens about their responsibilities in disaster risk prevention management.

Managing structural and non-structural measures to foster disaster risk prevention

Switzerland has a long and solid experience with natural disasters and their management. Over the last thirty years, the management of natural disasters underwent significant changes and developed into a modern, forward-looking risk management system that can serve as an example to many other countries. While structural measures for a long time have constituted the core of Switzerland's disaster risk prevention management, the last years have seen an increased use of non-structural measures along with a strong preference for "soft", nature-based measures.

Rather than fostering a reactive approach to disaster risk management, Switzerland has opted for an increasingly forward-looking system that integrates ecological, social and economic aspects in disaster risk prevention management and expects all actors of society to do their share for effective protection against natural hazards.

An exemplary whole-of-society responsibility for boosting resilience

Switzerland is an exemplary case of a country embracing a strong whole-of-society approach to risk management. The responsibility for risk management is shared across all relevant actors of society, from national and cantonal governments and municipalities over insurance companies, private sector actors to citizens and researchers. The approach

is based on the philosophy that a state's efforts are only effective if all other actors are contributing to risk management, both in terms of behaviour and investment.

Along with public measures, individual responsibility in the management of natural hazards has been a key priority in Switzerland. Individuals and businesses are expected to contribute to overall safety levels by investing in object-specific safety measures, adapt their behaviour to potential imminent disasters and in the case of businesses evaluate and manage the potential economic consequences of disasters. As a result, there has been a significant increase in the capacity to cooperate and coordinate strategies and policies across sectors, but some challenges exist. Much of the implementation of building codes and of low hazard (yellow) regulations for example relies on private responsibility and requires high citizen awareness and private investments. Although insurance companies may reduce or refuse damage compensation payments if disaster risk reduction measures were not adequately implemented, there is a certain moral hazard risk. In the absence of strict public enforcement, this could potentially have negative impacts on overall private protection levels, as is observed in the case of yellow level hazards, which account for half of filed insured damage claims. Another challenge lies in the circumstance that individuals have to carry a significant part of the financial burden of individual disaster risk prevention measures. Financial rewards for preventive measures can help increase the likelihood of individuals implementing all disaster risk reduction measures recommended for their property, including those that are not mandatory.

The national platform for natural hazards, PLANAT, takes a key role in bringing together representatives from the federal government, cantonal governments, research community, professional associations, private sector and insurance companies to work on three important areas of work to boost disaster risk reduction throughout Switzerland. Especially the role of insurance providers and individual citizens and businesses in reducing risks through behavioural measures and self-protection investments is significant. An evaluation of the actual take-up of disaster risk reduction measures across societal actors could in the future inform activities that aim at increasing whole-of-society contributions to disaster risk reduction.

The whole-of-society approach also benefited from Switzerland’s direct democratic governance tradition that has positively influenced disaster risk management by emphasising awareness and building acceptance for disaster risk reduction investments from the bottom up. Lengthy consultation processes have - more often than not - resulted in more efficient and effective disaster risk reduction investments.

A large stock of protective infrastructure protecting Switzerland

Protective infrastructure investments have been a core part of Switzerland’s disaster risk prevention measures. Cantons and municipalities share the responsibility to protect citizens and assets from natural hazards, but the financing and construction of protective measures is distributed between the national government, cantons, municipalities, infrastructure operators or other public or private authorities.

A large stock of infrastructure has been created since the early 19th century, much of which is aging and has been built in response to disasters rather than in a forward-looking

manner that takes long-term risk evolution into account. Aging infrastructure, along with sub-national maintenance budget constraints, may however contribute to exacerbating vulnerabilities in current infrastructure. Maintaining the existing stock of infrastructure is crucial, but challenging, especially in the absence of information on the status of maintenance and protection capacity. Efforts to build a central database on the level of maintenance of existing protective infrastructure are underway and show that Switzerland recognises this shortcoming. Once available the platform can help uncover possible gaps early on to prioritise maintenance investments and inform budgeting for maintenance finance needs in the medium term. It is however important that maintenance funding is not being made available at the expense of future infrastructure investment needs where no prior structural protection exists. It is also crucial that decisions for the construction of new protective infrastructure continue to embrace a forward-looking perspective that takes long-term risk evolution into account. This especially applies to local-level decisions, but is equally valid for cantonal and federal level decisions.

An increasing importance of non-structural disaster risk prevention measures

Systematically assessing major natural disasters and learning lessons for improving risk management has been fostered as part of Switzerland's disaster risk management culture. Since the late 1980's a paradigm change towards a greater use of non-structural risk management has been observed. Non-structural measures range from hazard mapping and land-use planning to risk communication and are important and cost-effective complements to structural protection measures.

Risk-informed land-use planning based on up-to-date hazard maps and the determination of protection levels for different types of land-use are key instruments to manage the risk exposure of people and assets. Although Switzerland has embraced this, some challenges remain. The gaps of locally available hazard and risk assessments have been closing rapidly for new construction projects, but are closing slower for older buildings. The integration of hazard and land-use plans has also not always been of the same pace across all municipalities and levels of government. In some cases, hazard information in land-use decisions appear to not have been adequately integrated yet or have not unlocked their full potential yet. Minor hazard (yellow) zones for example account for half of filed insured damage claims. It is recommended to speed up the process addressing this and to raise awareness for the need to respect regulations even in low hazard zones.

To further improve risk planning, it would also be desirable to speed up the integration of hazard and land-use plans, as well as the compilation and harmonisation of national level risk maps. Factors expected to influence risk patterns in the medium term, such as climate change, could perhaps also benefit from being implemented more rapidly into the risk mapping process to enable a swift adjustment of other risk management actions.

Even though earthquakes are assumed to be the hazard with the greatest expected amount of negative socio-economic impacts, only about half of the cantons have established maps of seismic soil foundation classes or spectral seismic zoning studies to account for the influence of the local soil on the earthquake hazard. The maps have only limited implications on zoning plans and do not lead to construction bans, which could

lead to significant damage in case of an earthquake. It would be recommended to provide more attention to seismic hazard when designing hazard maps.

Risk communication, organized at the national level through LAINAT and PLANAT initiatives and accompanied by the efforts of insurance providers and cantonal governments, has been a good example that shows the commitment of Switzerland to a whole-of-society approach to risk management. Despite the many innovative risk communication approaches, it remains challenging to maintain high risk awareness levels. Awareness is high after major disaster events, but decreases the more time has passed. For citizens that have not personally experienced the impacts of a disaster the awareness may often be even less persistent. Communication efforts are also not equally high across all hazards and appear especially low for low reoccurrence high impact disasters. Earthquakes, which despite their potentially substantial impact do not feature high in Switzerland's risk communication efforts, are a key example for this. Since Switzerland's direct democratic culture is strongly based on citizens' demands, citizens' awareness level can significantly influence the amount of public resources allocated towards disaster risk prevention management. High awareness across hazards is also a critical factor in ensuring that everyone – including citizens and the private sector - fulfils their responsibilities. It is important to evaluate the effectiveness of past and ongoing campaigns to ensure their efficiency in light of changing channels of communication.

Shared risk financing across all levels of government and society

Switzerland has invested significant amounts of resources in protecting their citizens and the economy against the negative impacts of natural disasters. Guided by the principle of solidarity, all levels of government as well as non-governmental actors and citizens have contributed to reducing risks stemming from natural disasters. Along with the public and private sector, individual citizens are expected to contribute to overall safety levels by investing in safety measures for their properties. However, in despite of these contributions – or perhaps because of them – picture of the flow of financial contributions by the different actors is not complete. Reviews on the total budget allocation for disaster risk prevention are not done on a regular or systematic basis and even the picture on public funding flows is rather fragmented, making the steering of funding towards priority projects difficult. In light of the parallel absence of vast information on the status of maintenance and protection capacity of existing structural measures, the risk that investment decisions are not made strategically enough is substantial and effectiveness of public funding may be compromised. It is recommended to centrally and regularly collect funding information across cantons and different non-governmental actors to better target and prioritise spending and to avoid that expenditure by different actors are undermining each other. Collecting funding information in a central and regular manner also enhances transparency and accountability.

A clearer picture of the total available resources is even more important in the future. With changing climatic conditions and other risk factors evolving in the future, Swiss authorities expect higher investment needs for protective measures in the future. At the same time, it is becoming increasingly clear that maintenance and rehabilitation needs for the large existing stock of aging infrastructure are set to increase too. To meet future disaster risk prevention investment needs, it is important to engage in longer-term

financial needs assessments and financial planning to avoid an increase in vulnerability to citizens and assets from the impacts of disasters.

Switzerland is a best practice example in terms of achieving near-universal coverage against natural disasters. Swiss citizens and businesses enjoy affordable access to full coverage of possible damages caused by the majority of natural hazard events. Insurance companies and Swiss authorities are very aware of the potential moral hazard risk that arises if insured households or businesses refrain from investing in self-protection measures to reduce eventual damages. In light of this, active campaigns have been launched to inform clients of their disaster risk reduction obligations. Insurance companies may also reduce or refuse damage compensation payments in case expected disaster risk reduction measures were not implemented. It is important to evaluate the effectiveness of past and ongoing campaigns to reduce the risk of moral hazard so as to improve the efficiency of natural disaster insurance in the future.

Notes

[1] http://www.bafu.admin.ch/umwelt/indikatoren/08596/08599/index.html?lang=en

[2] http://www.wsl.ch/fe/gebirgshydrologie/HEX/projekte/schadendatenbank/index_EN

[3] www.proclim.ch

[4] www.fan-info.ch

[5] http://www.alpconv.org/en/convention/default.html

[6] http://www.iksr.org/en/international-cooperation/about-us/index.html

[7] http://www.bafu.admin.ch/naturgefahren/14187/index.html?lang=en; http://www.bafu.admin.ch/naturgefahren/14186/14809/15591/index.html?lang=fr

[8] http://www.FOEN.admin.ch/naturgefahren/14186/14801/15746/index.html?lang=de

[9] https://www.geodienste.ch/

[10] *Tragwerksnormen des Schweizerischen Ingenieur- und Architektenverein (SIA)* (Norms for supporting structures of the Swiss Society of Engineers and Architects (SIA))

[11] http://v-ef.lehrplan.ch/index.php?code=b|6|4|1

[12] https://www.plandetudes.ch/shs_31#16914

[13] http://www.babs.admin.ch/en/aufgabenbabs/ski.html

[14] The Aquaprotect project, completed in 2008, is a joint venture by Swiss Re and FOEN to define flood hazard zones across Switzerland. Cantons without hazard maps covering the whole of their territory can use Aquaprotect to provide indications about the dangers of floods outside areas covered by hazard maps. The Aquaprotect, however, cannot replace hazard maps (FOEN, 2016c).

[15] http://www.svv.ch/en/consumer-info/non-life-insurance/swiss-natural-perils-pool

[16] https://www.fondssuisse.ch/de/fondssuisse

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