

The consideration of natural risk in land use planning

Comparison of three practices:
Valais, Switzerland,
Aosta Valley, Italy,
Rhône-Alpes and Provence-Alpes-Côte d'Azur, France.

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¹ *This paper uses corrected, completed or updated information from Anne Peltier's doctoral thesis "The management of natural hazards in the Western Europe mountains" defended in December 2005 and available for on-line consultation at the following address:*
<http://tel.archives-ouvertes.fr/tel-00078352/fr/>

1. Historical legal context

In the project partners' geographical areas, the public policies governing natural hazard management are largely based on integrating these hazards into local planning and on prevention through regulations on building construction. Zoning is considered the main tool for risk management. This regulation has occurred only gradually.

In Switzerland, the first form of regulation appeared in the 1930s: to avoid obstructing normal water flow, constructions on river banks had to be authorized (Valais cantonal law of 1932). Then, following the fatal avalanches in winter 1950–51, some cantons integrated avalanche zone maps into their town planning maps. In 1979, the *Loi fédérale sur l'aménagement du territoire*, the LAT (federal law on regional land use planning) took into account environmental hazards when master plans on the canton level were established regarding municipal zoning. In 1991, forest and the river management laws laid down the federal subsidization methods for natural risks. The federal recommendations for hydrological and geological hazard mapping date only from 1997.

In Italy, the first law concerning hazard zoning dates from May 1989 and aimed at land protection. It created the Basin Authorities, which intervene at the level of the river basin and its slopes and executes basin plans defining zones with specific prohibitions. The Aosta Valley embarked on hazard zoning well before the Italian national government. The first circulars (infrequently respected) appeared at the end of 1960 and in June 1978 a town planning law regulated building in hazard areas.

In France, the 1935 law created the *Plans des surfaces submersibles*: PSS (Sinkable Surfaces Plans) in which any construction likely to slow the water run-off was subjected to the prefecture authorization. In 1955, two articles of the town planning code (Article R 111-2 and R 111-3) made it possible to prohibit (or to authorize under certain conditions) building in natural hazard areas.

2. Responsibility, methodological tool and political procedure

2.1. Switzerland: Valais: natural risk management is the municipality's responsibility while under control of the canton

Municipal responsibility

In Switzerland, the legal-administrative responsibility of natural hazard management is subsumed under municipal responsibilities. The canton issues technical directives, authenticates hazard maps, approves the proposed protective measures, and grants the cantonal subsidy. The Swiss Confederacy issues technical recommendations and grants the federal subsidy for studies and protective measures only if they are undertaken according to the rules, standards and doctrine it has set out. In Switzerland, public money is the central element of high-quality protection against natural hazards except for earthquake-resistant protection of buildings, for which building owners are wholly responsible.

The hazard map

In Switzerland, hazard maps are drawn up according to federal recommendations, but there are some cantonal adaptations based on past experience and certain situations. They take into account the degree of intensity and the probability of occurrence of recognized hazards. The scale varies from 1/2000 to 1/10000. They include a technical report that contains the inventory of past events and the basic meteorological, hydrological, geological and geomorphological documents pertinent to the area. Phenomena and hazards are also described. The report determines and justifies the hazard perimeters on the basis of past and/or potential event scenarios. It proposes and sizes protective measures.

Crossing the hazard map with human occupation maps (human activity areas, road infrastructures, etc.) brings to light the lack of protection in these areas. Depending on its vulnerability, an object must be able to resist such an event with a predefined return period.

In Valais, three colors identify the degree of hazard on the map without taking into account the existing human-made protective measures at the time the map is drawn up in order to preserve the memory of the natural hazards affecting the local community. The protective effect of a structure appears on the map as a simple hatched area. This preservation reserve is

also present in the subsidy file, which can contain two different maps: one shows the degree of danger before the protective measure and the other shows the effect of the measure proposed by the study. Note that in Switzerland new buildings are authorized within the blue perimeter affecting a building zone protected by a subsidized work. Protective measures are therefore necessarily considered.

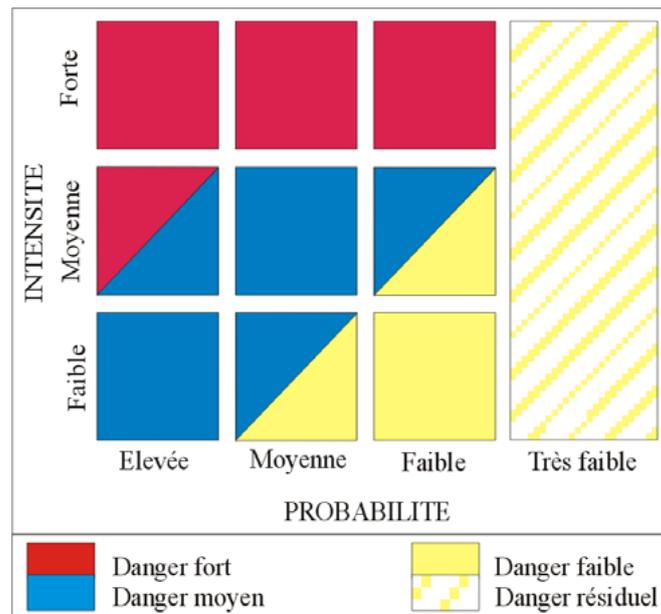
To remedy the lack of protection, the Confederacy doctrine favors land settlement and town planning regulations. As for new protective structures, subsidies are allowed only on the basis of a risk analysis of the object to be protected. This analysis is relatively sophisticated and should be further developed.

The consideration of natural risks in the Valais Canton

To take into account hazard maps in the confirmation procedure of the *Plan d'aménagement communal des zones*: PAZ (municipal development zoning plan), in 1987 Valais introduced an original article in its cantonal LAT [see above]. In four paragraphs, it unambiguously defined a hazard zone according to the law, the limitations to future construction, how it is to be transferred to PAZ and the conditions under which the owner affected by the measures ensuing from the creation of a hazard map can appeal. To establish the thematic coordination forms, which are the basis of the main cantonal plan for assigning human activity areas, the Canton then draws up the cantonal inventory of avalanches and slope instability sectors. On the basis of the 1997 federal recommendations and its own directives on the subject, it requests municipalities to draw up the water and slope instability hazard map for their area. Because of the fatal events of the 1950s, the avalanche hazard maps had nearly all been prepared before this time.

The hazard map is made by the municipality which calls on specialized private offices approved by the canton. The map is then validated by the canton and a public inquiry is opened: the owner who considers himself harmed by the possible restrictive effect of this map on his parcel of land can open an appeal against the cantonal executive. At the end of the procedure, the map is approved as a guide on the municipal PAZ. Other cantons do not proceed systematically in the same way: in the Grisons Canton, maps are drawn up by the cantonal forestry service.

According to the federal recommendations, hazard zoning is based on the combination of the intensity and the occurrence probability, with thresholds defined for every type of hazard. Three colors are usually used – red, blue, and yellow – corresponding to the degree of high, moderate, and low danger, respectively. The fourth degree (yellow/white hachures), which is used for indicating a residual hazard (very low probability of occurrence and high intensity), is rarely used except for flood hazards.



Hazard degrees used for hazard maps in Switzerland

(Source: OFEG, 2001, in Anne Peltier's doctoral thesis, p. 372)

Restrictions stemming from hazard maps

Every hazard degree implies appropriate restrictions. Their application varies slightly depending on the case and past experience:

- **Red** indicates a zone where no building intended to shelter people or animals is authorized. Extensions are also not authorized. Building zones that have no constructions and that are affected by this color are downgraded. Changes are authorized only if they decrease risk.
- **Blue** is a regulation perimeter inside which building is authorized on the basis of an assessment that establishes building measures and their sizing.
- **Yellow** is a regulated perimeter inside which building is authorized only if diverse individual protective measures are taken. The cantonal authority validates these measures.

- **Yellow/white** hachures correspond to a regulated perimeter inside which residents are subjected to measures such as an emergency evacuation plan or other previously defined collective measures.

NB: During geological hazard map creation, the precautionary principle sometimes prevails, especially since in-depth investigations are always expensive. In this case, the canton reserves the possibility of later revising the map's relevance on the basis of an assessment which may unambiguously contradict the value of the parameters prevailing at the time the initial maps were created. This scenario can be found in particular when gypsum is suspected deep underground, which cannot be verified because of a shortage of funds at the time map is drawn up.

The federal directives are clear: *“a hazard map is the representation of an existing hazard according to the judgment of an expert and has force of law only when it is validated by the cantonal authority. Application of the restrictions as regards legislation, planning or authorization procedures remains under the jurisdiction of the cantonal and municipal authorities.”* The federal legislation thus clearly distinguishes the role of the expert (demonstrating risk) and the cantonal and municipal authorities' responsibility (validate the hazard and integrate the risk into the land use planning).

In Valais, a hazard map is taken into account by the municipal authority as soon as it has been validated by the cantonal expert, even if the public inquiry procedure is not engaged or approved by the canton. This preventive use will be invalidated only if the public inquiry procedure and its ratification require that the map be modified. These hazard maps therefore differ greatly from French PPRs, which have a statutory value and can have effect against third parties.

2.2. Italy: Aosta Valley: an indicative zoning chargeable to the State

Although in Switzerland the cantonal legislation on natural hazards is a detailed application of federal legislation, in Italy, the national legislation came later than regional laws. Italy thus differs from Switzerland and France, given that several systems coexist. The national legislation is applied differently depending on the Basin Authorities or certain regional legislations. In fact, risk management and particularly zoning is quite heterogeneous. Every

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Basin Authority establishes its own risk zoning directives and certain regions or autonomous provinces enact their own regulations.

Throughout Italy, hazard mapping is done by the state as represented by the Basin Authorities created by the May 1989 law. These authorities are required to produce *Piani stralcio per l'assetto idrogeologico del territorio*: PAI (temporary development plans). Their objective is to provide a coordinated management of floods and landslide risks at the watershed scale. Only local authorities and the state are required to conform to the PAI (as in France with the SDAGE).

A first PAI was drawn up in the Pô basin in 1999, but a first planning document, the *Piano stralcio delle fasce fluviali*: PSFF (temporary river zone plan) had been adopted in 1998 for the entire basin. The PSFF outlines the areas liable to flooding during the reference floods and regulates land use (only for local authorities and the state). The PSFF distinguishes three zones in which it enacts specific land use regulations.

The Calabria floods in 2000 made it necessary to revise the PAI. The 2001 PAI resulted in a 1/25,000 hazard map (gravity, erosive, torrential and avalanche processes) over the entire watershed, considering that protection structures reduce hazard. It also lists the most vulnerable zones. The combination of hazard and vulnerability leads to a risk evaluation whose purpose is to define intervention priorities. The PAI distinguishes four risk classes (low, moderate, high, very high). On the banks of the main streams, the PAI summarizes PSFF zoning.

The PS 267

The Pô Basin Authority also drew up a plan intended to identify and treat zones subjected to high risk: the *piano straordinario per le aree a rischio idrogeologico molto elevato* (extraordinary plan for very high hydrogeologic risk areas) created by the N 267 law of August 1998. The PS 267 is more restrictive than the PAI because it enacts precise land settlement regulations which must be respected. Like the PAI, it takes into account protective structures but only local authorities and the state are under obligation.

In the Aosta Valley, 14 sites with very high risk, distributed over ten townships, were defined according to risk intensity and the urgency of preventive measures.

The Aosta Valley assigns risk zoning to the municipalities

In the Aosta Valley, the statutory zoning is governed by the regional N 11 law of April 1998. It stipulates that hazard mapping is a part of the municipal general regulating plan (PRGC), implemented by the municipalities.

Content

The hazard map concerns the entire municipal land area but at different levels of detail. Detailed maps are used for urbanized areas and less detailed maps for high mountain areas. The purpose was to accelerate the process of drawing up the maps by favoring the most threatened areas. The file, submitted to the region, contains several very complete technical maps and maps of areas that cannot be constructed (one map per hazard type: landslides, floods, avalanches). Avalanches mapped on cadastral maps at the 1/5000 scale for the entire territory and the 1/2000 scale for urbanized areas are integrated into the PRGC. Several reports are joined on these maps: the general report on the entire municipality and specific reports for every risk source. The objective is to highlight threatened areas. Therefore, the protective measures to be taken in every hazard area are presented, but without detailed analysis.

Procedure

As in Valais, the municipalities use specialized private offices to draw up these maps, but the municipality can freely choose the service providers. Technicians draw up maps in collaboration with regional authorities. The file is then passed on to the region, which has 120 days to approve (with or without reserve) or to reject the maps. If there is no answer, the map is considered approved. In theory, the municipalities had 1 year after the 1998 law was enacted to make their maps, but in 2000, only a small number had done so. When a municipality fails to carry out the orders, the region can theoretically draw up the maps, but this was rarely done.

Hazard zones

For the most part, maps delineate three zones corresponding to a low, moderate or high level of hazard. Although in Switzerland zoning is based on the combination of intensity and the occurrence probability, this is not always the case in the Aosta Valley. For example, for floods, the zoning law that summarizes the PSFF delineation distinguishes:

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- the A band: the portion of a river bed where most of the waters flow during the normal annual floods (approximately 20-year return flood);
- the B band: the part of the land area concerned by the reference flood (approximately 100-year return flood);
- the C band: the part of the area located outside of the B band that could be concerned by the most catastrophic floods.

The zones thus delineated are:

- red zone: high hazard or A band for floods;
- yellow zone: average hazard or B band for floods;
- green zone: low hazard or C band for floods;
- purple zones are not studied in detail but may be a source of risk.

Restrictions

In the Aosta Valley, there is no clearly shown overall regulation for every type of zone, as in Switzerland. Indeed, in every zone, the obligations vary depending on the hazards. Altogether, the compulsory restrictions are rather severe and, unlike in Switzerland, new buildings are forbidden in both red and yellow zones. As for avalanche risk, the resistance concept dominates in construction regulations.

2.3. France

In France, the statutory zoning of risks is made within the *Plans de prévention des risques naturels prévisibles*: PPR (prevention plans of predictable natural risks) created by the January 1995 law. The *Plan d'exposition aux risques*: PER (plan of risk exposure), created by the July 1982 law, was succeeded by the PPR. This law, which created a compensation system for natural disasters, tried to create a link between compensation and prevention. But the PER, too complicated and laden with procedures that were too long, did not produce the expected results. It was therefore replaced by the PPR, which replaced the previous tools (PSS, article R 111-3 perimeters and PER). It strengthened the contents and goes beyond simple risk zoning. It can prescribe preventive or protective measures that must be carried out by local communities or private individuals, but its specificity is to establish town planning or building measures.

The PPR is now one of the essential prevention tools. It is the state's responsibility; it is particular to France and it leads to acceptance problems.

Note that in the future, all the municipalities exposed to natural risks will not systematically be the object of a PPR, a powerful but cumbersome tool, either because of the existing risk (considered moderate) or because of the programming by the state services.

Nevertheless, the consideration of natural risks is an obligation of the town planning code for all town planning documents without exception. There is a "light" substitution method in areas where the state does not require a PPR:

- posting the risk by "porté à connaissance préfectoral" (prefecture information procedure) or
- the municipality drawing up a hazard map that will be either directly integrated into its town planning document (*Plan local d'urbanisme*: PLU, municipal land use plan) or taken into account on a case-by-case basis in City Hall's town planning decisions (town planning certificate, planning permission in application of the R.111.2 article of the town planning code), with no additional statutory framework.

Given how onerous it is to elaborate and update the PPR, the municipalities seem to use first and foremost this "light" method where PPRs have not yet been required. At the end of 2006, 5370 municipalities had an approved PPR and 3850 a required PPR (not approved).

Content

The PPR includes a presentation note, graphic documents and a regulation. The presentation note explains and justifies the initiative. It is required to justify the choice of a reference hazard as a reference for the entire regulation.

The file contains several maps:

- the informative map of natural phenomena listing the known phenomena;
- the hazard map prioritizing the phenomena according to their frequency and intensity and generally classifying the events in three levels (high, moderate, low);
- the activity map, so the best adapted prevention tool and regulation can be chosen;
- the zoning plan transfers onto a map the statutory choices based on risk evaluation (a combination of hazards and activities) and the dialogue with all the risk management actors. It delineates zones directly exposed to risks said to be danger zones, and not

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directly exposed zones called precaution zones, where changes in land use can aggravate the risks or create new ones.

For every type of zone, the regulation defines how the projects will be implemented, used, and exploited. It also defines measures of prevention, protection and security that local communities and private persons are required to take. It clarifies planning, land use and exploitation measures of the existing possessions that the owners, users or developers are required to take.

Procedure

The prefect, who represents the national government in the department, requires the PPR in a delineated territory and for indicated risks: the notion of a risk basin is the most important. This means that the township (or townships) scale is preferably used for mountain-type risks (by treating them all simultaneously, if possible: multirisk PPRs). The watershed scale (or part of the basin) should also be preferably used, in particular to treat plain flood problems coherently. The PPR is carried out under the decentralized state services' responsibility, and specialized private offices can help them if necessary.

In every step of the PPR, a dialogue with the municipalities concerned is ongoing so as to reach an agreement. In fact, the zoning step often leads to delicate negotiations.

The PPR project is passed on to the town council for deliberation and to diverse bodies for opinion. It is also subjected to public inquiry. According to the deliberations, opinions and the investigating commissioner's conclusions, the project is then approved (or not approved) by "arrêté préfectoral" (prefectural order). If a disagreement with the municipality arises, the prefect can disregard its opinion (but this is infrequent). The approved PPR is considered a public utility constraint and can have effect against third parties. After the approval of the PPR, the mayor has 3 months to attach it to the PLU.

In addition, the approved PPR can be disputed in the administrative jurisdictions. Any modification of a PPR leads to a resumption of the entire PPR administrative procedure. The approved PPR is the departure point of a chain of diverse measures:

- for the owners, the measures must be applied for the existing (with the problem that neither the state nor the insurance gains control);
- statutory measures must be applied, with no possibility of modification, in the town planning certificates and planning permission (even if complementary studies exist);

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- the mayor is required to inform the population periodically;
- compulsory implementation of a *Plan communal de sauvegarde*: PCS (municipal safeguarding plan) in which it is recommended that the exceptional phenomena be taken into account (which, by definition, are not directly considered in the PPR);
- compulsory information of the owners and occupiers during every act of acquisition or rental.

The PPR also facilitates state grants and the non-increase of insurance deductibles.

Risk zones

Zones directly exposed to risks

The distinction of these zones mainly depends on the suitability for construction criteria for future projects. The procedure is first based on hazard levels:

- high hazard zones: the rule of thumb is banning construction;
- moderate hazard zones: the rule of thumb is for the most part banning construction, particularly in zones that have not yet been urbanized; in the authorized zones, the projects are required to respect strict requirements adapted to the structures present;
- low hazard zones: simple requirements must limit the vulnerability of property.

The procedure then integrates elements of land use and the structures in place. A distinction is made between the natural spaces to protect such as flood expansion zones, urbanized spaces and urban areas, and the spaces located behind protective structures.

Zones that are not directly exposed

These are spaces located near the directly exposed zones that can aggravate hazard phenomena by runoff, or sectors located upstream of the watershed where the control of rainwater is necessary not to increase the river discharge.

Color-coded zones

- red zone: the rule of thumb is banning construction projects;
- blue zone: construction projects must respect certain requirements;
- specific colors or shades can be used to represent zones with a particular function: flood zone expansion where construction is forbidden, zones that are not directly exposed where risks can be aggravated and which are subjected to particular regulations, wooded spaces with an established protective function, spaces located behind protection works, zones of likely maximal avalanche activity, etc.

Restrictions

Restrictions are defined by the regulation that must improve human safety and limit and at times reduce vulnerability.

Project regulations

The term “project” includes all the buildings, structures, developments or agricultural, forest, artisan, commercial or industrial uses which may be implemented. The projects that entail enlargement, change in destination or reconstruction after a disaster are regulated as projects, even if they concern existing property.

The regulation clarifies the conditions in which work can be carried out. Town planning rules must be respected: bans and requirements for any type of building, structure or development. Building requirements must also be respected: the contracting authority is responsible for implementing building codes. The regulation also clarifies the terms of use which are the regulations related to property use as well as the conditions of use.

The measures of prevention, protection and security that must set the local authorities, network administrators and establishments and private individuals

Preventative measures have, for example, the objective of improving hazard knowledge through specific studies, the implementation of surveillance and alert systems, informing populations, etc. Protective measures aim at reducing hazards by diverse works. Safeguard measures aim at reducing the vulnerability of persons: rescue plans, identification of refuge spaces for establishments open to the public, etc.

The measures on existing property and activities

These measures require owners, users or operators to take measures related to any type of building, structure, etc. and can involve the arrangement of this property, its use and its exploitation. The measures related to the arrangement of property can concern human safety: refuge spaces in case of flood, consolidation of structures for earthquakes, closing any opening in walls exposed to avalanches, etc. They can also involve limiting damage to property: cofferdams in case of flood, moving expensive installations (boilers), etc.

The PPRs can only impose measures if their average cost is 10% lower than the market value of the property. Since 2005, money from the *Fonds de prévention des risques naturels majeurs*: FPRNM (prevention funds for major natural risks) can be used for these measures. These funds are acquired from a levy on insurance premiums related to the natural disaster

guarantee. It was created to finance expropriation for public safety reasons by the February 1995 law. This expropriation was designed to oblige inhabitants to leave places exposed to highly damaging and very high risks (risk for human life). The acquisition of their property (without considering the risk in the estimation made by tax authorities) must allow them to settle somewhere else. This expropriation is possible only for landslides, avalanches or torrential events, and if the cost of protective structures is higher than the property value.

2.4. Cross-border comparison of natural risk management policies in land planning

Reflection on the risks in land use planning policies of the Aosta Valley, Valais and France (Rhône-Alpes and Provence-Alpes-Côte d'Azur) brings to light a number of similarities:

- Today, in these countries, natural risk management is based on prevention through regulations on building in risk zones. Statutory zoning is an essential tool in this management. This policy has been implemented since the 1950s and its relevance and even its necessity were brought to light because of the pronounced development of urbanization. Its implementation was gradual, with sometimes not very decisive attempts and with different rhythms in the three countries. In Italy, there are also perceptible differences between the Basin Authorities and Regional Authorities. This statutory natural risk zoning policy is not present in all European countries and the four partner regions of the PRINAT project are certainly in the forefront of reflection and practices in this domain.

- There are a number of similarities between the three types of zoning. In France, we speak about risk zoning, but in fact it is hazard zoning, and its principles are rather close. Indeed, risk zoning (in the etymological meaning of the word) would be for example a blue perimeter in which the municipal authority would have defined an x density of buildings. This density corresponds to limiting the living space. In that case we could speak about risk zoning and risk maps. However, this level of technical precision of land use management is not yet in practice.

The differences:

1. The number of statutory zones (besides a zone without particular restrictions) varies from two in France to three in Italy and Switzerland. Swiss zoning is comparable to 3 + 1, given that the yellow/white hachures [see section 2.1] are generally used only for flood hazards. In France, zoning has become more precise but it is still based on three hazard levels and two statutory zones: not suitable for construction and suitable for building under certain conditions.

Note that in France, for most of the mountainous phenomena, particularly when they involve severe damage and intense (thus fatal) events, the tendency is to favor two hazard levels (high and moderate). From a statutory point of view, this implies the prevalence of a classification into zones that are not suitable for construction. Note finally that, given the long-standing zoning in certain areas (the mountainous areas in particular) and its pioneering nature without a truly national framework, practices can still diverge slightly at the local level. In the last few years, the national services have been trying to homogenize practices (notably at the level of the hazard grids) through methodological guides led by the Ministry of Ecology and Sustainable Development.

2. The restrictions also vary: in the Aosta Valley, zones of high and moderate hazards are not suitable for construction for new for buildings, except for avalanche risk, while in Switzerland only high hazard zones are deemed unsuitable for building construction. France shows more subtle nuances for moderate hazard zones.

3. In France and Switzerland, hazard mapping is more complex than simple statutory zoning. To remedy the lack of protection, the doctrine of the Swiss Confederacy favors land use planning measures and urban development regulations over construction of protective works. In France, the PPR regulates construction projects but it can also impose prevention, protection and security measures, as well as measures concerning existing property and activities.

4. Considering the political and administrative traditions of each country, regulations related to natural risks in land use planning are not implemented in the same way.

In Switzerland, hazard maps are only transferred to the municipal zoning as a guide. This underlines the potentially progressive nature of hazard, which can evolve in one direction or another. It also transfers the legal responsibility of how regulations are enforced within hazard

zones to elected representatives. In case of damage due to the forces of nature, the owner who considers that the rule was not applied can invoke the responsibility of the municipality or the canton.

In Italy, indicative zoning, which is the state's responsibility, can only be imposed on national and local authorities. In the Aosta Valley, risk mapping is a part of the PRGC (municipal general regulating plan), undertaken by the local authorities and approved by the region.

In France, the approved PPR is considered a public utility and can have effect against third parties. The mayor then must attach it to the PLU (local town planning).

5. Drawing up hazard maps and the related regulations are very different.

In Switzerland, these maps are drawn up under the authority of the municipality (or the canton for its infrastructures), which commissions specialized private offices or institutes approved by the canton. They must be validated by the canton.

In Italy, indicative zoning is drawn up by the Basin Authorities. In the Aosta Valley, as in Valais, the municipalities also use specialized facilities to draw up hazard maps, but these are freely chosen by the municipality. Maps are then approved by the region.

In France, the state decides to require PPRs, draws them up and approves them by prefectural order. The study procedure, led by specialized private offices, RTMs, etc., mostly examine archives and existing studies and makes a detailed field assessment, with no substantial complementary studies. In every procedure, a dialogue is maintained with the municipality, which is required to deliberate the project. In case of disagreement, the prefect can disregard the opinion of the municipality (which is unusual).

These modalities and particularly the very different role the municipalities play show that the hazard maps are generally better accepted by the municipalities (and therefore their inhabitants) in Switzerland and in the Aosta Valley, which is undoubtedly related to the local nature of the decisions. However, other factors, certainly as important, intervene in this acceptance, such as the precise criteria used to delineate a hazard zone: thresholds and return periods as well as the problem of managing existing properties and finally the flexibility of the statutory document (whether or not the planned regulations can be locally adapted).

3. Thresholds and return periods

With repetitive phenomena such as floods and avalanches, hazard mapping implies that a hazard and/or a reference scenario was previously defined. It is this hazard that is taken into account in the prevention measures; it corresponds to a return period chosen according to the objectives set out.

Floods

Water heights and flow speeds are taken into account in Switzerland and France. But the chosen thresholds are rather different.

In France, the reference event in land use planning to be remembered for zoning is conventionally “the highest known flood or the 100-year return flood if this is greater.” The hazard levels (low, moderate, high) are then determined according to the intensity of the physical parameters of the reference event (the hydrogeomorphological method is used for plain floods). These parameters are mainly water heights, flow speeds as well as flooding duration.

For plain floods, the hazard is considered high when the water height exceeds 1 m or, if it is lower, when the speed is considered high (> 0.5 m/s). For torrential floods, given the specificity of the solid matter transport, we aim to take into consideration the probability of the phenomenon’s reach and the intensity. As a result, the low hazard often becomes relatively confined. Large dams are an exception because the considered hazard is the 10,000-year return flood in terms of public safety.

In Switzerland, high hazard is when the water height exceeds 2 m or when the product of the speed and the water height is greater than $2 \text{ m}^2/\text{s}$. The Swiss criteria for delimiting liable flooding zones are thus much more flexible than the French criteria.

In the Aosta Valley, delimitation of liable flooding zones (which summarizes the PSFF delimitation) is made according to other criteria:

- the A band, high hazard: the portion of the river bed where most of the waters flow during the annual normal floods (approximately 20-year return flood);

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- the B band, moderate hazard: the part of the area concerned by the reference flood (approximately 100-year return flood);
- the C band, low hazard: the part of the area situated outside of the B band and which could be concerned by the most catastrophic floods.

On this point, the comparison with the two other countries is rather difficult.

Avalanches

As regards avalanches, the three countries adopted the same delimitation criterion: the pressure exerted by the avalanche (but without each country clarifying whether this means the dynamic pressure within the avalanche or the impact pressure on an obstacle). The high hazard threshold is also identical: 3 t/m^2 , but there is a slight difference with the reference hazard. In Switzerland, the reference hazard is an avalanche with a 300-year return period; in the Aosta Valley, it is at least a 100-year return period; in France, it is a 100-year return period for buildings and the likely maximal avalanche for human life.

On the other hand, the criteria differ slightly for delimiting low and moderate hazard zones. France adopted the most restrictive criteria (moderate hazard: pressure between 0.1 and 3 t/m^2), the Aosta Valley is the least strict (moderate hazard: between 0.5 and 3 t/m^2) and Switzerland is between the two others (between 0.3 and 3 t/m^2).

Mass movements

Comparison is difficult because there are perceptible differences between the types of events taken into account and because the criteria used are for the most part qualitative.

We can only compare the criteria used for rock falls in Switzerland and France. Trajectory software can calculate the height of flight and the kinetic energy E of blocks affecting the zone concerned. In Switzerland, in zones approved for development, hazard is considered high if $E > 300 \text{ kJ}$, moderate if $30 < E < 300 \text{ kJ}$ and low if $E < 30 \text{ kJ}$. Most of time, the same values are used in France.

Workshops during the Interreg RISKYDROGEO project studied the landslides of Trièves (near Grenoble) and Montagnon (Valais). They brought out a more pronounced severity in the acceptability of risk in France than in Switzerland. However, this must be put into perspective. Indeed, the comparison of these two cases demonstrated that Switzerland invests greater resources for investigation and implementation of stabilization measures, as seen in Montagnon compared to Trièves.

Degree of risk acceptability

Finally, this comparison tends to demonstrate greater acceptability of natural risks in Switzerland than in Italy or France. This may be partially due to Switzerland's federalism which gives cantons total responsibility for natural risk management. This contributes to a certain local freedom to appreciate this acceptability, which is not the case for the Italian regions and even less for the French national government. France is much stricter and the thresholds used are the most restrictive.

The Aosta Valley establishes thresholds only for avalanches, with values identical to those used by her two neighbors for high hazard and with intermediate values for moderate hazards. Regulations for moderate hazard zones are generally stricter in the Aosta Valley than in the other countries because they are generally not approved for development (except for avalanche zones).

4. Existing structures

Risk prevention through hazard mapping clashes with a fundamental problem: future urbanization. However, numerous buildings already exist in risk zones. What are the measures taken to remedy this situation? They include reducing either vulnerability or hazards.

In Switzerland

The zoning logic responds to this question: if there is a deficit in protection, measures must be taken to reduce it. Of course, these measures are proportional to the value of the object to be protected and are based on consequent investigations.

For example, since 2003 in Montagnon (Valais) there has been an attempt to lower (with some success) the hydrostatic pressure exerted by the water table on the sliding surface of landslides, resulting in a marked decrease of movements. At the same time, the law allows changes in authorizations to build or transform. Within the red danger perimeter, only maintenance of existing structures is authorized. Within the blue perimeter, building will be authorized only if very strict construction measures are implemented, often relatively disadvantageous for property owners. And so forth, depending on the hazard's level of danger.

Naturally, within the red perimeter the most seriously affected owners were compensated on the basis of a total disaster and their building was destroyed with a ban to rebuild.

In the Aosta Valley

The 1998 law regulates the modifications that buildings situated in risk zones can undergo. In zones exposed to high risk, only security, restoration and extraordinary maintenance works are authorized (with slight differences depending on the hazard). New infrastructures are also allowed, except roads. In zones exposed to moderate risk, rehabilitation, restoration or enlargement work on existing buildings can be done (but no planning permission for new buildings, except in the moderate avalanche hazard zones). The January 2005 law relaxes these rules for landslides: the region can undertake or authorize works to protect economic and social interests in zones exposed to high risk levels. A specific evaluation of the structures' stability is planned and the impact of potential of protection works is estimated.

In France

The PPR allows the authorities to act on existing structures (see above). The basic principles are the following:

- interventions on existing buildings should not increase the vulnerability of the construction by enlarging the surface or increasing accommodation facilities;
- works reducing risk are authorized;
- development leading to a population increase in high-risk zones is forbidden;
- limited extensions necessary to respect the standards of habitability or safety are allowed;
- repairs or reconstructions after a disaster are authorized only if the inhabitants' safety is ensured and property vulnerability is reduced.

The PPR also makes it possible to impose measures on private parties (within the limits of 10% of the property's market or considered value) and developers.

5. Expropriation

When protection is too expensive or impossible, expropriation is a solution to reduce the risk.

In Valais, property is sometimes expropriated, but this is an unusual situation.

In the Aosta Valley, after the October 2000 floods, the June 2002 law was voted to resolve the problem of numerous buildings exposed to high risk that could not all be protected. The region provides a grant to relocate and to make public works and buildings safe when situated in zones subjected to hydrogeological risk. Public buildings or those for residential use situated in zones exposed to high risk (and possibly those situated in moderate risk zones, if the region agrees) can be relocated. Relocation is voluntary; therefore it is not exactly an expropriation.

In France, the law provides for recourse to expropriation. Great threat to human life must be proved and the expropriation must be less expensive than the other possible measures to protect people concerned. The *Fonds de prévention des risques naturels majeurs*: FPRNM (prevention funds for major natural risks) funds these expropriations (see above). Amicable acquisition is now possible but it is strictly supervised by the state, as in cases of expropriation.

In these three countries, existing buildings raise serious problems for the authorities. These countries have implemented measures to decrease vulnerability and built protective structures to reduce hazards. Switzerland has focused on the protective works. The question in zoning is to know whether these works are taken into account.

6. The consideration of protective structures

This is a delicate point in risk zoning policy. The consideration of works can lead to an increase in vulnerability in exposed zones. But not taking them into account can turn into criticism by elected representatives and the populations that pay for protective works and want these protected zones to be approved for development.

In Switzerland, the consideration of protective structures is totally assumed by the authorities. Integrating these works into hazard mapping resulted in two maps: a map of the current hazards and a map of future hazards after development and protection measures were implemented. But the works are taken into account only after they are built and if their long-term maintenance is provided, a substantial limitation. Even in this case, the zone in which the danger was decreased by a protective measure retains its original color to remind the local community of the initial danger to which it would be exposed again if the work were to be poorly maintained.

In Valais, practices vary depending on the type of risk. For rivers, the works are widely taken into account to establish the maps of current and future hazards. However, they are not considered a factor of absolute safety: generally, a zone protected by a structure will not be classified as a white zone because it is considered that there is always a residual risk. However, these works must be considered because only then can a zone not approved for development be transformed into a zone approved for development.

For avalanches, the canton policy is less flexible. Offsetting protective works in avalanche trigger zones does not entail modification of the hazard zones. Thus new zones approved for development cannot be created. Only dams and deviation dikes are taken into account, provided that they are sufficiently large.

For landslides, this depends on the nature of the phenomenon. For example, the destruction of threatening boulders makes it possible to modify the hazard zone and to authorize building with no other particular protective measures.

In Italy, the PAI and the PS 267 take into account protective works.

In the Aosta Valley, hazard maps are not required to take into account protective works (as in Valais) except when the law stipulates the contrary. Consequently, the 15 February 1999 resolution specifies: *“areas exposed to a natural risk must be determined without considering existing protective works, except when the technical criteria for determining the diverse spaces not approved for development have other explicit information available. Protective works can be one element of risk reduction only in already urbanized zones for which the PRG regulates land use by taking into account the indications of the technical reports of phenomenon analysis.”*

An already urbanized area can thus be made denser if it is protected, but it is necessary to distinguish diverse possibilities depending on the types of hazard.

In zones subjected to avalanches, the protective works can make it possible to build underground works of public interest in high-risk zones, under certain conditions. New infrastructures and agricultural or pastoral buildings with exclusively seasonal use are authorized with basic structural resistance indications. More broadly, avalanche risk maps can be revised to take protective structures into account. For floods, protective works are taken into account to delineate high- and moderate-risk zones only if they are in good condition. On the other hand, the low-risk zone cannot be reduced because a risk always continues, even after structures have been constructed (residual risk).

In France, the directives on implementing the PPR specify that the protective works have not to be taken into account for delineating hazards. However, exceptionally structures can be taken into account, provided that there is no other possibility of urbanization and that the reliability of the works is guaranteed by an identified contractor, as well as long-lasting diagnosis and maintenance requirements. Construction in new zones cannot be allowed but can intervene for certain interstitial spaces in urban zones. A PPR can be revised to take these principles into account. On the other hand, the PPR must not authorize conditional suitability for construction.

Comparison of the consideration of protective works

There is a significant difference between the three countries discussed herein. France has the strictest and the most restrictive policy. Building in protected zones is exceptional and is subjected to numerous conditions. In the Aosta Valley, the consideration of protective works remains quite rare but numerous exceptions are possible. In practice, most professionals prefer not to make an evaluation of the building efficacy because of lack of knowledge on the structure in question. Considering Switzerland in general and Valais in particular, the impact of protective works is transferred to hazard maps and assumed by the authorities concerned.