Swiss Strategy on Natural Hazards

Risk-based spatial planning

Synthesis report on two case studies at communal land use planning level

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Contents

1. What is risk-based spatial planning?

The damage caused by natural hazards has risen steadily in recent decades, despite considerable expenditure on defences. One reason is an ever denser and more intensive use of space, and the extension of land usage to hazard areas.

To date, the need for defence measures has been derived primarily from hazard maps, and has thus focused more on the hazard than on the actual risk of damage. Action is focused on red and blue hazard areas, defined as follows:

Threat level		**Current focus of action**
Substantial threat	red	>Planning measures (conditions, building ban) >Technical defence measures
Moderate threat	blue	
Little threat	yellow	>Advisory notices, no restrictions >Individuals encouraged to take indep. precautions
Residual threat	yellow/white	

In this context, risk is defined as the probability of a hazardous event multiplied by the extent of the potential damage. However, high risks often do not occur in areas where the threat level is substantial or moderate, but in areas of little or residual threat (yellow and yellow/white hatched) in which land use is intensive. This could be observed with the flooding of August 2005, for example[1].

A change of perspective is required to limit the increase in risk and the rising cost of damage. The focus must be shifted more towards land use and the associated potential damage. This demands an approach based on the type of use, its intensity and its susceptibility to damage. Determining land use that is adapted to the hazard and risk situation is thus one of the key tasks of spatial planning. **Risk-based spatial planning**, which factors in all threat levels, is an approach which identifies and visualises current and possible future risks. The risk trend can thus be managed by avoiding new and mitigating existing risks. The principle is to impose planning conditions in all areas in which a threat exists.

Threat level		**Future focus of action**
Substantial threat	red	>Planning measures (conditions at all threat levels, relocation, building ban) >Explore technical defence measures >Encourage individuals to take indep. precautions
Moderate threat	blue	
Little threat	yellow	
Residual threat	yellow/white	

The foundation for risk-based spatial planning was laid in 2005 with the publication entitled 'Spatial planning and natural hazards' (ARE et al., 2005). Even then it was suggested that plan-

[1] 'The Floods of 2005 in Switzerland: Synthesis report on the event analysis', p. 8. "It is particularly striking that approximately one quarter of the private damage was concentrated in the industrial and commercial zones of Emmen-Littau (in the canton of Lucerne) and Altdorf-Bürglen-Schattdorf (in the canton of Uri). In these two areas alone, the flood damage came to a total of over CHF 500 million".

ning conditions should be examined for yellow and yellow/white hazard areas, in addition to those under greater threat.

The risk-based approach was also taken up again in the 'Security Level for Natural Hazards' publication (PLANAT 2013). It calls for the security level that has been achieved to be maintained primarily by managing how space is used. Particular emphasis is placed on avoiding new and unacceptable risks (Figure 1).

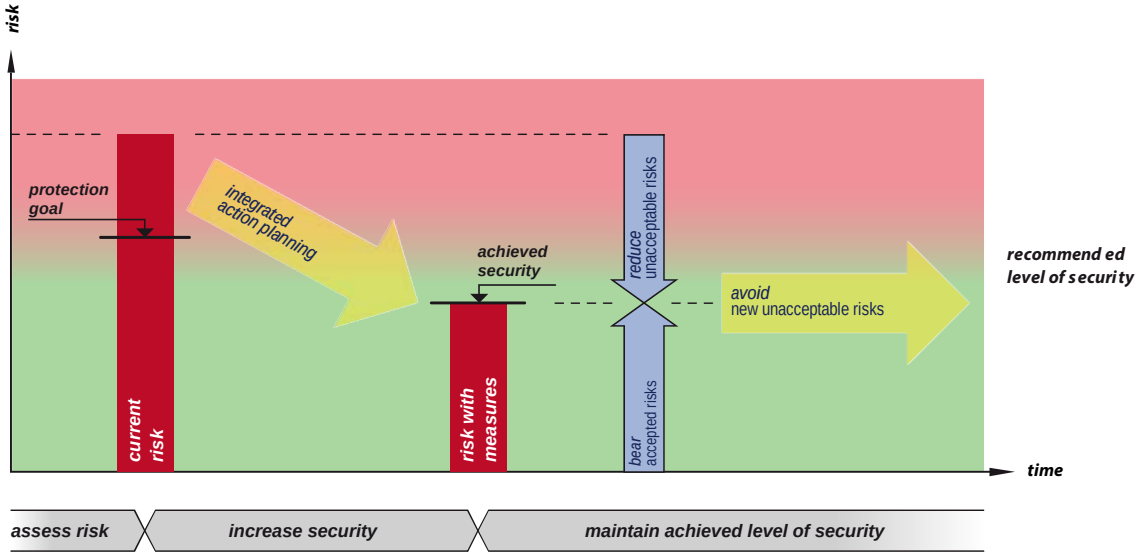

Fig. 1: Procedure for achieving and maintaining the target level of security (PLANAT 2013)

Two case studies were conducted to determine the finer points of a risk-based approach to spatial planning: one in the Rhine Valley in the canton of St. Gallen, and one in the Bündner Herrschaft – the district in the canton of Graubünden which has the town of Maienfeld at its heart. The project examined the following questions:

- Based on the individual hazard process, how can land use be made risk-appropriate using planning tools? What needs to be in place for this to happen?
- How should a risk-based land use plan look?
- What aspects must be taken into consideration in the building permit process?
- How can these aspects be addressed systematically?

This synthesis report presents the case studies in the St. Gallen Rhine Valley and the Bündner Herrschaft. It summarises their key findings, lists the open questions, and provides an outlook for the next steps. **The report provides an overview. It is aimed at planners, experts in natural hazards and others involved on the implementation side of spatial planning.** The findings produced by these studies are intended as an initial contribution to a generally applicable set of guidelines that will be drawn up at a later date. Before this can happen, the open questions (see Section 4) must be answered, and the method must be tested in practice in further case studies.

2. The case studies

2.1. Approach and characteristics

The objective of the case studies was to identify the central aspects of risk-based spatial planning and to develop a methodical approach geared to the practical application of planning instruments. Beginning with the specific hazard situation and land use in the St. Gallen Rhine Valley, a decision-making tree was developed and then tested using theoretical examples. In a second step, this method was applied – and further refined – in the Bündner Herrschaft case study (see Figure 10, Appendix A1).

The approach developed in the case studies enables the most important planning aspects to be identified from a series of questions. This then permits a targeted risk evaluation of an existing or planned use of land.

Both case studies concentrated on land use planning at commune level. That in the St. Gallen Rhine Valley concerned a strategy for defence measures, and that in the Bündner Herrschaft involved translating the hazard map into a hazard zoning plan.

The aim of the case studies was to pinpoint conflicts between land use and natural hazards, and to identify options for mitigating the attendant risks. Although deliberations referred to actual buildings, certain theoretical assumptions had to be made with regard to more intensive usage or rezoning. This was so that the risk-based spatial planning approach could be illustrated and discussed with as wide a range of examples as possible.

A further advantage of using theoretical situations was the freedom to test and discuss measures which would change the type or intensity of land use, or reduce vulnerability. In reality, responsibility for this would lie first and foremost with the commune-level planning authority. The case studies did not involve these authorities, neither did they have any effect on actual plans or decisions.

The two case studies looked at a land use background that was as broad as possible. The two test areas differ as follows with regard to natural hazards and land usage:

	St. Gallen Rhine valley	Bündner Herrschaft
Hazard process	Static flooding (gradual process)	Dynamic flooding, rock fall (sudden process)
Intensity	Low to high	Low to high
Advance warning period	Long	Short
Land use	Urban and industrial	Rural and tourism-related

The main difference between gradual (static flooding) and sudden (dynamic flooding, rock falls) processes is their predictability and advance warning period, as well as their intensity. Only under special circumstances is there any advance warning of sudden processes, and where rock falls are concerned there is generally no warning at all. Dynamic flooding and mudslides must be analysed on a case-by-case basis to establish whether or not there is sufficient time to respond. With gradual processes such as static flooding, there should usually be enough time to take the necessary precautions.

2.2. The St. Gallen Rhine Valley case study

The sections that follow will present the individual examples from the case study, and discuss the spatial planning considerations concerning the planned type of land use. The map extract given below shows the hazard situation in the test area (Figure 2).

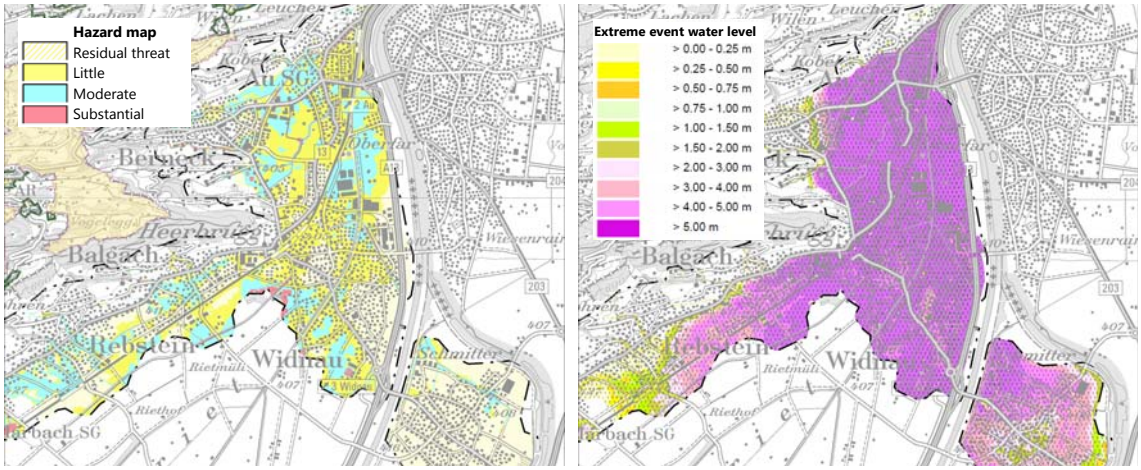

Fig. 2 left: Hazard map for the Rhine valley; right: Intensity map>HQ300

2.2.1 Assumption: expansion of a retirement and care home within a developed building zone

Assumed change of use and threat level

The retirement and care home is located within a densely built-up neighbourhood of single-family homes (Figure 3). The assumption is that the current site will be expanded to provide a regional care home for those requiring an elevated level of care. The site has been chosen in view of the synergies with the existing retirement home. It thus makes no sense to relocate within the commune.

The investigated land use is in an area of residual risk. According to the intensity map, extreme flooding would be classified at a high level of intensity (burst dam, flood depth of 4–5m). In view of the high floodwater level involved, it would not be possible to protect the buildings adequately. The two lower floors would therefore have to remain "unused", which is difficult to justify on the grounds of operating efficiency, accessibility for those with disabilities, etc.

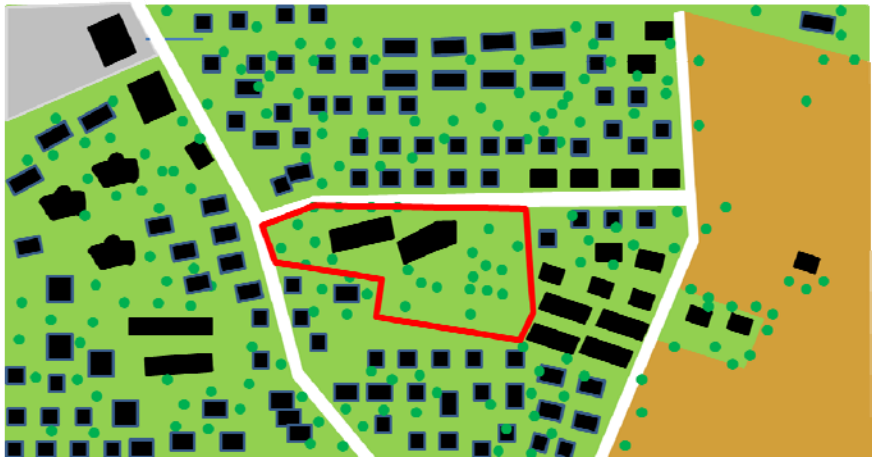

Fig. 3: Assumption: expansion of a retirement and nursing home within a densely built-up neighbourhood of single-family homes

Risk considerations from the planning perspective

For cost reasons, it is not possible to protect the buildings completely up to the potential floodwater level. However, the design of the new building should ensure that people and material assets can be evacuated easily. Furthermore, property damage can be reduced by choosing materials which are as resistant as possible to water, or which are easy to clean and dry, or which cost little to replace. Furthermore, the building systems and all devices and products which are of vital importance to the residents must be accommodated above potential floodwater level. Precautions such as these also help to ensure that residents can return as quickly as possible following an event.

As a general rule, buildings like these that serve a public interest should preferably be constructed outside areas that are liable to flooding. In view of the very low probability of an event occurring, and a sufficient advance warning period, the expansion of the planned care home at the present site may nonetheless be considered if the residents can be evacuated in time. The project plans must include an evacuation strategy which provides evidence that people and material assets can be evacuated, and of appropriately equipped space for the residents and moveable property on the floors above potential floodwater level. The feasibility and practicability of these measures must be ensured with emergency drills.

Starting point:	intensification of use
Hazard type:	very rare static flooding
Hazard intensity:	high
Threat level:	yellow/white hatched
Advance warning:	sufficient advance warning period
Possible conditions:	building defences not realisable, but measures to reduce damage can be taken (arrangement of building contents, water-resistant materials)
Danger to persons:	low
Evacuation:	possible
Alternative site:	not available

Conclusion: land use may be intensified subject to conditions and an emergency strategy.

2.2.2 Assumption: intensification of land use and new construction within an existing business zone

Assumed change of use and threat level

The business area that was the subject of the study is bordered to the east by the Rhine Valley canal, and to the south by a minor stream that runs along a purpose-built channel. Residential areas lie immediately to the west (Figure 4). The test area in the business and industrial zone covers a fertiliser and pesticide merchant, as well as that company's own land reserves in the neighbouring business and industrial zone. This latter area has been zoned but not yet developed. The study assumed a more intense use of the present building stock by increasing storage capacity or the toxicity of the substances stored. Furthermore, it was assumed that the company

would expand into the neighbouring reserve land, although the precise land usage was unknown.

The hazards attached to the site are a 100-300-year flood to a height of one metre, as well as extreme events with floodwaters of up to five metres.

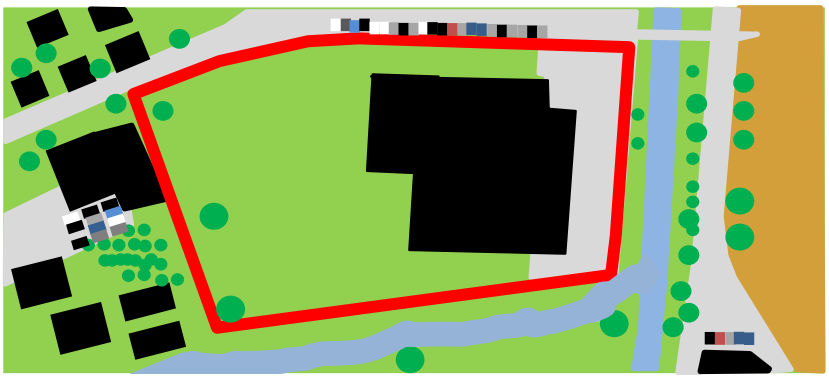

Fig. 4: Assumption: intensification of land use in existing business zone

Risk considerations from the planning perspective

In view of the toxicity to the environment of the substances it stores, the fertiliser and pesticide company is subject to the Major Accidents Ordinance and included in the corresponding list. The risk assessment is therefore the responsibility of the cantonal executive bodies, not that of the communal planning authority.

To avoid risks to persons and property, as well as secondary risks, usage restrictions must apply to spaces below the potential floodwater level, and a minimum height set for the ground floor. In the case of new buildings, it would be worth considering a regulation to assess the property's defences against a 300-year event. This would certainly be advisable in many cases.

Given the possibility of an extreme event, it would be appropriate to ban sensitive properties with a high potential risk below the potential floodwater line for such events. Regulations on maximum (evacuable) volumes of substances carrying a contamination risk should also be examined, as should measures to move such substances to upper floors.

Starting point:	intensification of use
Hazard type:	rare and very rare static flooding (two sources)
Hazard intensity:	medium, high for an extreme event
Threat level:	blue
Advance warning period:	-
Possible conditions:	property defences against rare events, usage conditions
Danger to persons:	low
Evacuation:	-
Alternative site:	no, existing usage
Conclusion:	**intensification of land use advisable only with property defences and conditions for use**

2.2.3 Assumption: single family home zone with subsequent densification and rezoning

Assumed change of use and threat level

The area in question is a two-storey single family home zone with some undeveloped plots, and others that are underdeveloped based on their plot-to-building ratio (Figure 5). The assumption is that usage of some of the developed plots could be densified by constructing extensions and additional storeys on existing homes. A further assumption is that consideration is to be given to rezoning the neighbouring agricultural zone as a two-storey residential zone.

Most of the land covered by the study is in a moderate (blue) threat area. The hazards in question are 30-year floods to a depth of 0–75cm, 100-300-year floods to levels of 1–2m, and an extreme event with flooding up to 5m.

Since the test area consists of a developed section and a section that is to be newly designated a building zone, the two sections must be assessed separately. While it is possible to densify land usage in the existing building zone within the current zoning regulations, the development of the neighbouring agricultural zone must first be approved in a land use planning process.

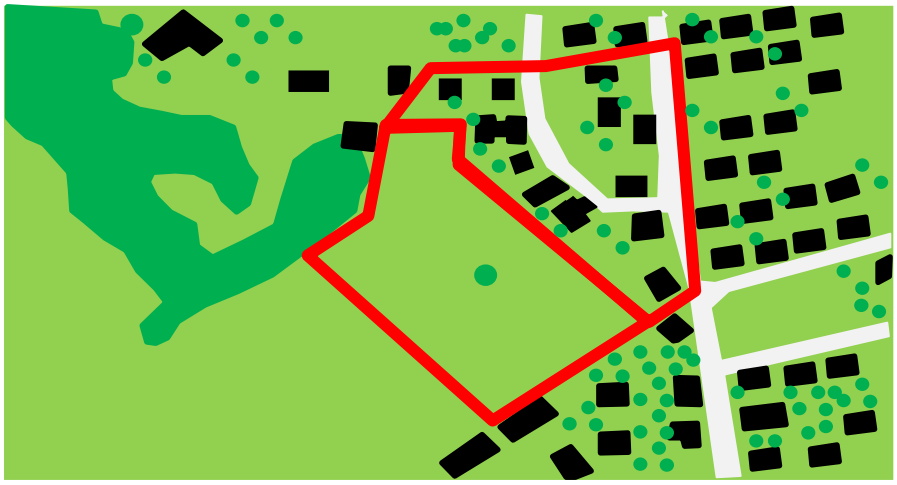

Fig. 5: Assumption: single family home zone with subsequent densification and rezoning

Risk considerations from the planning perspective

Densification of the single family home zone: The upper storeys of the homes in the area would be affected only if there were an extreme event. The construction of additional floors would even offer the benefit of evacuation upstairs. No further action would appear necessary here, unless ground and cellar floors would have to be remodelled. Extensions would be affected in the event of frequent flooding, however. Although precautionary regulations for new parts of the building – such ground floor height, the height of door and window openings, and whether or not living space should be permitted at basement level – would be advisable, they cannot be ordered as a condition of the building permit. There is no sufficient basis in law because any damage would be to material assets only. Whether or not this legal foundation could be created on the basis of a special land use plan[2] would have to be investigated. Special land use plans

[2] In the canton of St. Gallen, the planning authority can issue a land use plan for a particular district at any time against the will of the land-owners, providing it is lawful, practicable and reasonable.

can require property defence measures, restrict usage, and ban construction and certain types of use. Such regulations are legally binding. It would seem important for communes to issue these special land use plans not on a case-by-case basis, but according to an overall strategy on protection against natural hazards that is laid down in the communal structural plan. Other important factors include a review of whether, given the risk considerations, the neighbouring agricultural area is suitable for rezoning as building land, or whether there might be alternatives available within the commune.

Rezoning of agricultural zone and subsequent development: A special land use plan should be drawn up to counter frequent low-level flooding. This plan should set out regulations for the height of residential floors, cellar door and window openings, the proportion of building plots that can actually be built on, and living space at basement level. Flooding to depths of more than one metre occurs less than every 100 years. Since upper storeys would offer the advantage of vertical evacuation, it would seem appropriate as a general rule to require buildings to have at least two floors. Furthermore, high-value material assets should be accommodated above the flood line. The chosen materials should be as water-resistant as possible, and building components easy to replace. Unless disproportionately high costs are incurred, the possible precautionary measures against extreme events with floodwater levels in excess of five metres are very limited. Were an event of such magnitude to occur, the entire territory of the commune would be flooded. There is thus nowhere better in the commune to build single-family homes. In view of the hazard situation, the planning authority must investigate whether alternative forms of housing, such as apartment blocks, should be constructed instead. The advantage of this would be that the lowest two full floors at most would be affected in the case of an extreme event. Furthermore, it is worth considering approaches in which the ground floor would be used not for residential purposes but extensively, for cellars, garage space, etc. Architecture and types of use which limit the risk should be investigated.

Starting point:	intensification of use and rezoning
Hazard type:	frequent to very rare static flooding (two sources)
Hazard intensity:	low to medium, high for an extreme event
Threat level:	blue
Advance warning:	long advance warning period
Possible conditions:	property defence measures, building conditions, restrictions on use, bans on construction or usage, adapted building types, special land use plans
Danger to persons:	low
Evacuation:	possible
Alternative site:	not available within the commune
Conclusion: usage may be intensified by adding storeys and imposing conditions; rezoning possible with overall risk minimisation strategy (special land use plan)	

2.2.4 Summary of the St. Gallen Rhine Valley case study

The examples show that appropriate planning measures can reduce the damaging impact of static flooding on new or more intensive types of land use (theoretical, in this study). Long advance warning periods and the rare occurrence of extreme flooding mean that measures to evacuate to higher floors or away from the area concerned are advisable. Restrictions on the way certain storeys are used, as well as building regulations for residential floors, methods of construction, and for the arrangement of door and window openings, and the building's contents also make sense. In industrial and business zones, it is important to have conditions such as those on the storage of environmentally harmful substances. It is also worth investigating alternative sites within the local area or in other communes at an early stage. The latter nonetheless requires a broader regional or cantonal perspective, or even planning at this level.

2.3. The Bündner Herrschaft case study

The sections that follow will present the individual examples from the case study, and discuss the spatial planning considerations concerning the planned type of land use. The map extract given below shows the hazard situation in the test area (Figure 6).

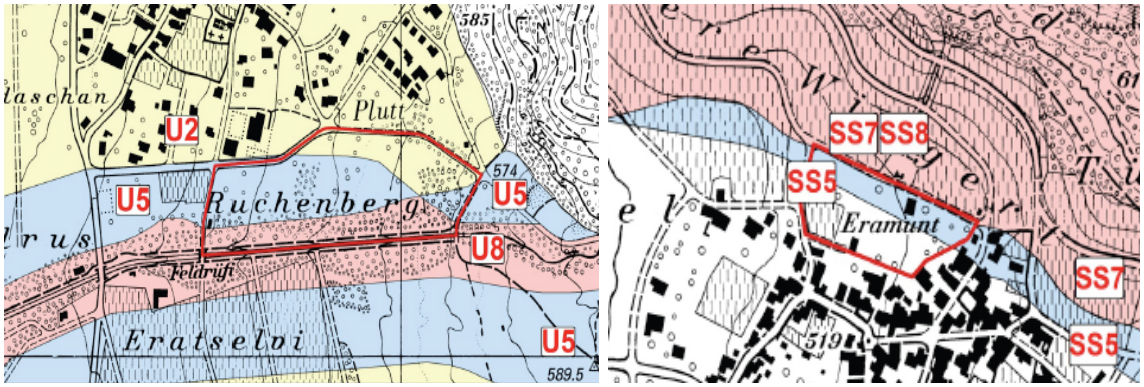

Fig. 6: Hazard map for the test area; left: water hazard map; right: rock/landslide hazard map.

2.3.1 Assumption: new residential area on the edge of the village in an existing building zone

Assumed change of use and threat level

The study concerns a residential area that is currently under construction. The area was set out on the basis of a special land use plan (site plan). Two apartment buildings are currently under construction. The second part of the area is as yet undeveloped (Figure 7). Projects for developing the entire area have already been drawn up. A moderate threat level applies to part of the area, while part is subject to a low or residual threat. It is known that both flooding and bank sedimentation can originate from both the lateral banks (from the south) and the direction of flow (from the east) of the neighbouring stream. Flooding of a medium process intensity (defined as a flow depth of 0.5–2m, or a flow depth x flow rate of 0.5 –2m^2/s) can be expected in the moderate-hazard area. Sediment deposits and erosion are also possible. This means that the ground and lower floors – generally used as living, garage and cellar space – would be particularly affected by an event, which would be expected to cause damage as a result of water ingress and debris. The canton of Graubünden requires reinforced building methods in moderate-hazard areas[3]. Project plans must also be reviewed by a building surveyor from the official GVG cantonal buildings insurance authority. A three-step process ensures that property defence measures are put in place for all building projects in blue hazard zones.

[3] In the canton of Graubünden, hazard maps are implemented in the form of communal hazard zone plans. Appropriate conditions apply to substantial (red) and moderate (blue)-level hazard areas. Areas of little (yellow) or residual (yellow/white hatched) hazard are freely accessible and visible to all on the online hazard maps. However, these areas are not included in the (hazard) zone plans, and are not subject to any restrictions. The GVG cantonal buildings insurance authority has developed an information sheet for building projects in yellow hazard areas. It addresses additional premiums to cover damage by natural forces, and voluntary property defence measures (in progress).

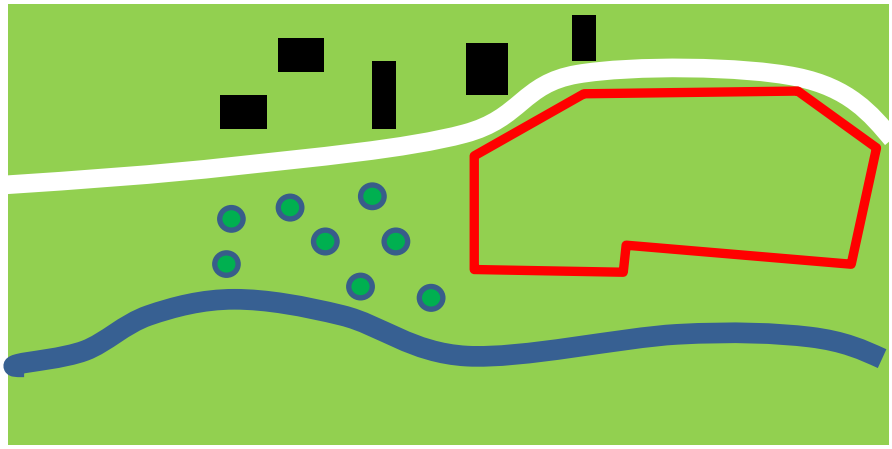

Fig. 7: Assumption: new residential area on the edge of the village

Risk considerations from the planning perspective

Property defence measures concerning individual elements of the buildings (e.g. the position and size of door and window openings, and the dimensions of the building envelope) are advisable. When factored in to project planning at an early stage, they generally result in only a minor increase in costs for the developers, and may be regarded as reasonable. Owing to the short advance warning period, particular attention should be paid to the risk to persons in outside areas, and the later planned accordingly. Furthermore, the siting and arrangement of high-value material assets should be as appropriate as possible to the hazard situation (e.g. indoor parking).

With newly-built housing in particular, it might be worth providing for defence measures that protect a number of properties at the same time (such as dams to divert water, and sufficient drainage), and putting water management measures into effect as construction is progress. This would result in better protection for the whole of the new neighbourhood. The caveat is that such water management plans would have to be drawn up at an early stage, so that they are known about when the special land use plan is produced. The building permit process offers only limited scope to formulate such conditions.

Starting point:	special land use plan (already zoned)
Hazard type:	dynamic flooding
Hazard intensity:	low to medium
Threat level:	yellow and blue
Advance warning:	short advance warning period
Possible conditions:	reinforced construction, requirements as to the position and size of door and window openings, multi-property defence measures, design of outside areas
Danger to persons:	present
Evacuation:	possible to a limited extent
Alternative site:	not available within the commune

Conclusion: land use can be intensified only subject to property defence and precautionary measures.

2.3.2 Assumption: rezoning to accommodate the construction of a new resort at the foot of a slope

Assumed change of use and threat level

The test area is currently used for agriculture. It is on a slope on the edge of the vineyards (Figure 8). The area is on the edge of the historical village centre, which has a dense pattern of residential and commercial buildings. The assumption is a new resort development, with a hotel, restaurant and indoor/outdoor pool and spa complex. This will significantly intensify land use. The agricultural zone is to be reclassified as a resort zone to enable the resort to go ahead. The northern edge of the site is at risk from rock falls (moderate hazard: intensity of 30 < E < 300kJ, recurring every 30-100 years), and of flooding from two gullies (little threat).

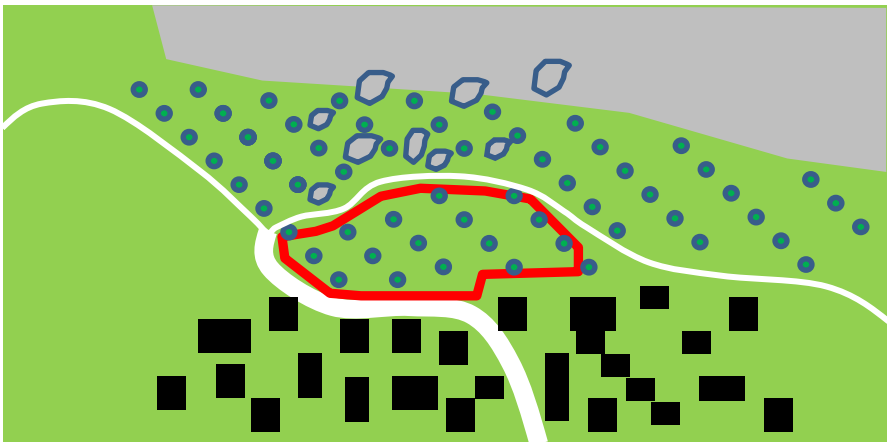

Fig. 8: Assumption: new resort development at the foot of the slope

Risk considerations from the planning perspective

First of all, the impact of the hazard on the site must be considered. Although protection measures such as netting or a retention dam could be installed to ensure safe usage for leisure purposes, they are both expensive and complex. The effect on the landscape is also considerable. In view of the rock fall hazard, in particular, and the usage of outside space associated with the resort, the site is unsuitable for its planned use. A regional alternative must be sought. This should be possible, because the planned use is not dependent on this particular site.

Starting point:	rezoning
Hazard type:	rock fall and dynamic flooding
Hazard intensity:	medium (rock fall); low (flooding)
Threat level:	blue
Advance warning:	none for rock falls
Possible conditions:	not possible to impose conditions that will protect people outside
Danger to persons:	people outside are at risk
Evacuation:	not possible
Alternative site:	explore regional alternatives

<u>Conclusion:</u> the site is not suitable for its planned use; the project is not tied to this particular location; reasonable precautionary and property defence measures cannot reduce the risk

2.3.3 Assumption: additional building to be added to a school

Assumed change of use and threat level

It is assumed that an additional building is to be constructed immediately adjacent to the existing primary school building, with its multi-purpose facility and outbuildings, as well as the recreation and play areas (Figure 9). A natural stream runs alongside the south of the planned site. The area is currently used for agriculture. The new building, in the legally designated zone for public buildings and facilities, is intended to house classrooms for craft and technology lessons, group rooms, the pre-school and the 'lunch club' dining room with day nursery. A recreation area is also planned. In contrast to the site of the existing school building, the extension building is in an area at moderate threat subject to flooding and overbank sedimentation (30-100-year event, flow depth of 0.5–2m, flow depth x flow rate of 0.5–2 m^2/s) and borders an area of substantial hazard on the stream side.

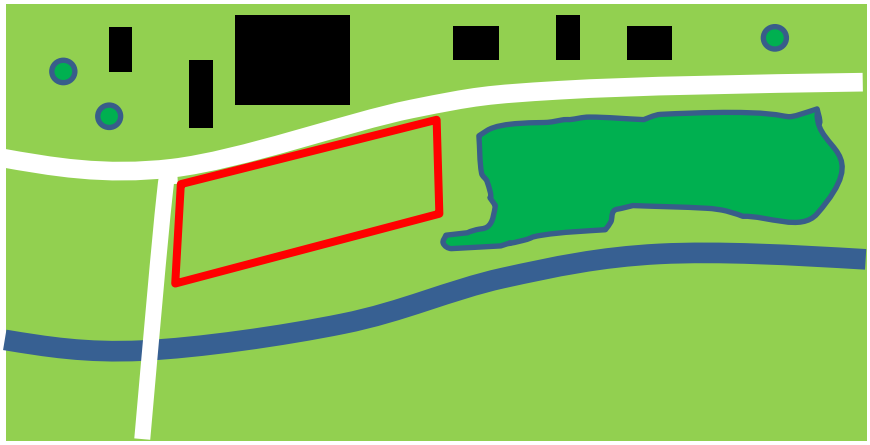

Fig. 9: Assumption: new school building

Risk considerations from the planning perspective

A wide range of land uses are permitted in a zone designated for public use. In the present case, in which the type of use is known, reasonable building defence measures might mean that certain features of the building's use are pre-ordained by the planning authority, in addition to the review of the planning application by the cantonal buildings insurance surveyor: no outside space, entrances or major openings in the building envelope where the stream flows towards the building. To ensure that this is complied with, when the area is rezoned a section that is located in hazard zone 2 (blue) should be subject to a planning order as a basis for further project work. If the problem is not identified until the building surveyor reviews the planning application, project development costs have already been incurred, and reworking the building project will result in additional costs.

In this case, the commune would be the developer, so it is possible to factor action into plans at an early stage. This would also be the case with a private developer, if the information were available and communicated in good time. It would also be advisable for protective structures to take the wider area into consideration, i.e. including the neighbouring residential plot, instead of being applied to only one property. Ideally, such measures would be determined as binding on land owners, thereby taking into account the shifting of the hazard to third parties.

Starting point:	intensification of use
Hazard type:	dynamic flooding
Hazard intensity:	medium
Threat level:	blue
Advance warning:	short advance warning period
Possible conditions:	no outside space, entrances or major openings in the building envelope where the stream flows towards the building; reinforced construction; multi-property defence measures.
Danger to persons:	present
Evacuation:	possible to a limited extent
Alternative site:	not available

Conclusion: the new school building is tied to the site in question; construction to be considered only under strict compliance with extensive precautionary and property defence measures.

2.3.4 Summary of the Bündner Herrschaft case study

The examples presented here show that, where there is the danger of sudden hazard processes such as rock falls and dynamic flooding, structural measures are necessary to protect the property or properties concerned. It is particularly easy to incorporate property defence measures into new building, at low additional cost. The scope for action is nonetheless more restricted than in the case of gradual processes, because the primary risk is to people. Broad measures which protect the whole of a particular district, for example, should thus also be considered. Here, too, alternative sites should be explored. Development should be rejected for land uses that bring large numbers of people together in one place, as in the (theoretical) resort case study.

3. Case study findings

The following conditions must be met for risk-based spatial planning to be implemented successfully:

- a simple, systematic process that is geared to spatial planning
- up-to-date data and documentation on hazards and – where available – risk
- knowledge of current and future land use (cooperation with private individuals required)
- familiarity with and acknowledgement of the scope for spatial planning action
- close cooperation between planning and natural hazard experts
- involvement of the risk bearers concerned (e.g. insurance companies)

3.1. Systematic approach

Risk-based spatial planning, which focuses on the communal level of land use planning, is aimed at visualising and managing current and future risks. It shows the scope that is available for the necessary planning measures to reduce risk. The case studies showed that a systematic approach makes sense. The decision-making tree applied here (see Figure 10, Appendix A1) and its subsequent iterations offer one approach. The individual stages in the deliberation process must be documented transparently to ensure that the reasons for spatial planning decisions are clear. A standardised decision-making flow chart is of limited use, however, because the individual contexts differ too widely in terms of the hazard situation, types of use, planning instruments and legal requirements at cantonal level.

Before individual projects are assessed, it is worth looking into an outline strategy for the area as a whole, which addresses multi-property defence measures, the possibility of shifting the hazard and/or a special land use plan, if necessary.

Risk-based planning analyses and documents current risks, the options for action, and the residual risk which remain after action has been taken. The measures that are to be instituted generally achieve a high level of acceptance once these aspects have been pointed out.

From the case studies, the researchers derived a set of key questions that must be answered to support and guide the evaluation of risk in the process of balancing planning interests (see Appendix 2).

3.2. Up-to-date hazard fundamentals

The very latest data and documentation must be used for risk-based spatial planning. For example, before an evaluation is made, the available hazard information must be checked to ensure that it is up to date, that it covers all defence structures, and gives a complete picture of risk processes. Where available, scaled intensity maps can be used to analyse risks and determine conditions.

The findings from the St. Gallen Rhine Valley case study indicate that, in addition to usage-specific information, the nature of hazard processes (sudden or gradual), as well as their intensity at different levels of probability, must be known and evaluated for all activities which impact on space and land use. Hazard maps are of only limited use in providing this important information. Intensity maps are more relevant when it comes to assessing risk in the context of planning interests and drawing the right conclusions for action. They offer a better picture of the impact of the hazard or situation, and thus permit the type of measure and the form it should take to be identified more effectively.

In contrast to the St. Gallen Rhine Valley, no scaled intensity maps exist for the Bündner Herrschaft test area. Here, the analysis must be based on the hazard maps and communal hazard zone plans. Despite the absence of intensity maps, the hazard maps still indicate the probability and intensity of hazard processes. Further information is required, however, from reports on hazard assessments, and expert opinions on the effect of individual defence structures.

The action plans that exist at commune level in the canton of St. Gallen also proved to be an important basis of data. They provide an overview of planned defence measures, be they technical, organisational, or individual property-related. Based on these plans, greater attention can then be focused on usage-specific measures.

3.3. Acknowledgement of the scope for spatial planning action

The case studies revealed differences in the available scope for formulating spatial planning measures. Factors include the nature of the changes of use that are planned, and what planning procedures are already underway, or will be necessary. The practical application of risk-based spatial planning may thus begin at a variety of different points.

3.3.1 Rezoning

It is essential that aspects of risk-based spatial planning are investigated at an early stage where land is to be rezoned (or included within building zones for the first time) in areas at moderate, little or residual threat. This enables site-related decisions to be made prudently in the knowledge of possible new risks. The following key questions should be considered when land use plans are being drawn up:

- Is the land use concerned dependent upon or tied to the site in question, or might there be alternatives? Have any such alternatives been explored?
- If usage is dependent upon the site in question: are the potential risks bearable (personal injury/property damage)? Can appropriate measures – such as different construction methods or evacuation plans – reduce the risks? If the site is important from the regional, cantonal or national perspective, then questions related to risk must be asked at an earlier stage, at cantonal or national structural or sectoral plan level.
- Is there sufficient information about the planned land use to permit the risks to be investigated?
- Does an investigation of the risks conclude that certain usages must be restricted, either spatially or in terms of the type of use?
- What is the potential for planning defence measures which cover a broader area, such as neighbouring plots, or action coordinated with neighbouring districts?

3.3.2 Intensification of use

Scope for action on the spatial planning front is more restricted where more intensive use is to be made of usage zones which have been determined by law. In some cases, special land use plans (such as development and site layout plans) may be able to influence the aspect of buildings and the form of property defence measures. A more common method, however, is to impose conditions as part of the building permit process. The individual measures must nonetheless be proportionate and reasonable. Where sudden processes such as rock falls are concerned, particular attention must be paid to outside space, which can often be protected only at great expense. In the case of natural hazards with sufficient advance warning periods, conditions may include measures such as evacuation strategies – although it is not always possible in practice to ensure that these remain active, or to conduct regular audits.

3.3.3 No ongoing spatial planning process

It is difficult to pursue risk-based spatial planning outside the framework of ongoing planning or building permit processes. It is nonetheless possible to make key actors more aware of the issues involved. These actors include the communal authorities themselves, but also land-owners, business owners, tenants, and developers. Beyond the settlement concerned, it is particularly important that those involved in agriculture and in operating leisure facilities are familiar with the idea of land-use planning on the basis of risk. Outside of ongoing planning processes, spatial planning measures cannot be ordered or prescribed. Rather, they rely on the willingness of those concerned to put them into practice. In cases in which there are high risks to material assets, there might be a discussion with insurance companies about financial support for the necessary property defence measures. However, a commune can also take independent action to revised its land use plans for areas of elevated risk. Alternatively, it can use the communal structural plan to determine binding measures which the authorities must subsequently implement as part of planning or building permit proceedings.

3.4. Close cooperation between spatial planning and natural hazard experts

One of the clear findings of the case studies was that risk-based spatial planning demands a deep familiarity with the prevailing hazard processes, and that knowledge about the attendant risks must also be acquired. Experts must be engaged to ensure that risk processes are evaluated properly. Information on the risks must be gathered in close cooperation with key actors such as first responders, insurance companies and private individuals. The planning measures and regulations that derive from this must be appropriate to the hazard processes and risks concerned. The risks that remain must permit adapted, risk-aware land use, without creating new and unacceptable risks. Close cooperation between planners, experts on natural hazards and other actors is absolutely essential in the intelligent handling of risk, and the development of effective solutions.

3.5. Specific measures are process-dependent

Once the prevailing hazard processes have been identified, the next question is whether or not people and material property can be moved to safety in good time. In most cases, it will not be possible to evacuate all assets, although furniture and smaller moveable property can usually be removed. Methods of construction must therefore be able withstand natural hazards, or be as resistant to them as possible. Building systems must be arranged so that the building can function again as quickly as possible, and interruptions minimised, in the event of an incident.

It is particularly important to ask how capable the affected population is of moving itself to safety independently. Depending on the event, it must be assumed that the emergency services will be very busy. Whether or not those affected could escape to higher floors or roofs as part of the evacuation plan (vertical evaluation) should therefore be examined. As a general rule, evacuation options should be integrated in to management-level contingency planning. Questions should also be asked at an early stage about the period for which evacuation is possible, and how quickly the evacuated individuals can return. It may be that evacuation is entirely impossible, in which case other, immediate action must be stipulated instead.

The degree of uncertainty involved in evaluating the processes at hand and their intensity, the effectiveness of measures and the advance warning period, for example, is often greater for sudden processes than for gradual ones. Particular care must therefore be taken with sudden processes, and new forms of land use should remain the exception.

4. Open questions

The case studies were not able to investigate all of the questions that are raised in the implementation of risk-based spatial planning. The following issues must therefore be addressed in greater depth in future projects:

- What legal foundations and tools are required at the various levels to implement risk-based spatial planning?
- How can risks be recorded and evaluated? In addition to the qualitative risk assessment, must they also be quantified?
- How can risk-based spatial planning be practised if there no current proceedings (land use planning, building permit, etc.) ongoing? How can the commune motivate land-owners to adapt the way they use their property? Might insurance companies provide support in such cases?
- How should 'red' hazard areas be treated in risk-based spatial planning?
- What solutions are there to the cantons' differing approaches to implementing hazard maps in spatial planning, especially where yellow and yellow/white zones are concerned?
- What should be done if the type of land use is not yet known, or subsequently changes?
- How can the threat to property and assets (buildings, contents, (temporary) business closures, etc.) be factored in to risk-based spatial planning, and how do land-owners, insurance companies and the public sector share existing and new risks?
- What aspects must be considered outside of building zones (plans for alternative uses, infrastructure, agricultural operations and leisure facilities, etc.)?
- How can the risks attached to other hazard processes be incorporated into risk-based spatial planning (surface runoff, ground water, back water in the sewerage system, etc.)?

5. Summary and outlook

The analysis of case studies on risk-based spatial planning showed that the approach has specific practical applications, and that existing data and documentation on natural hazards can be put to good, targeted use. It is also clear from the studies that the earlier that risk-based planning is incorporated in the overall planning process, the greater the scope for planning action. At this stage, alternative sites can be explored, or land use adapted in the best possible way to the risk situation. The scope for action contracts as the process progresses, but effective options are still available.

The case studies represent the first steps towards a systematic approach to evaluating existing or planned land uses, and deriving planning measures to reduce risk at communal land use plan and building permit levels. The decision-making tree in the appendix must nonetheless be redesigned in the interests of clarity, and a commentary provided.

At the same time, an effort must be made to awaken interest in risk-based spatial planning. The actors concerned, such as representatives of communal and cantonal authorities, planning offices and insurance companies must be shown the need for a more conscious way of dealing with hazards and risks. Greater support is also required to ensure close cooperation between planners and experts in natural hazards. This must also include those who actually bear the risk. The concept of risk-based spatial planning should not be restricted to land use planning alone, but should be applied at all levels of the planning process – structural plans, land use planning, and building permit proceedings.
The plan for the next step is to take the findings from this and other current projects on risk-based spatial planning as input for a new set of guidelines, or to revise the 'Spatial Planning and Natural Hazards' recommendation (ARE et al., 2005). Before this can happen, however, the open questions must be examined in greater depth, and the method tested in further case studies.

6. References

PLANAT, 2013: *Security level for natural hazards.* Bern

Esther Casanova Raumplanung and tur GmbH, 2013: *Risikobasierte Raumplanung in der kommunalen Nutzungsplanung*. Case study 2 (PLANAT project A6). (unpublished)

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Federal Department of the Environment, Transport, Energy and Communications, 2008: *The Floods of 2005 in Switzerland. Synthesis report on the event analysis.* Bern

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Appendix

A1 Decision-making tree

The decision-making tree was originally developed by Strittmatter Partner AG for the St. Gallen Rhine Valley case study. In a second step, it was applied – and further refined – by Esther Casanova Raumplanung und tur GmbH in the Bündner Herrschaft case study.

The decision-making tree represents a work in progress. The next step will be to test the individual steps, and specific questions, in practice.

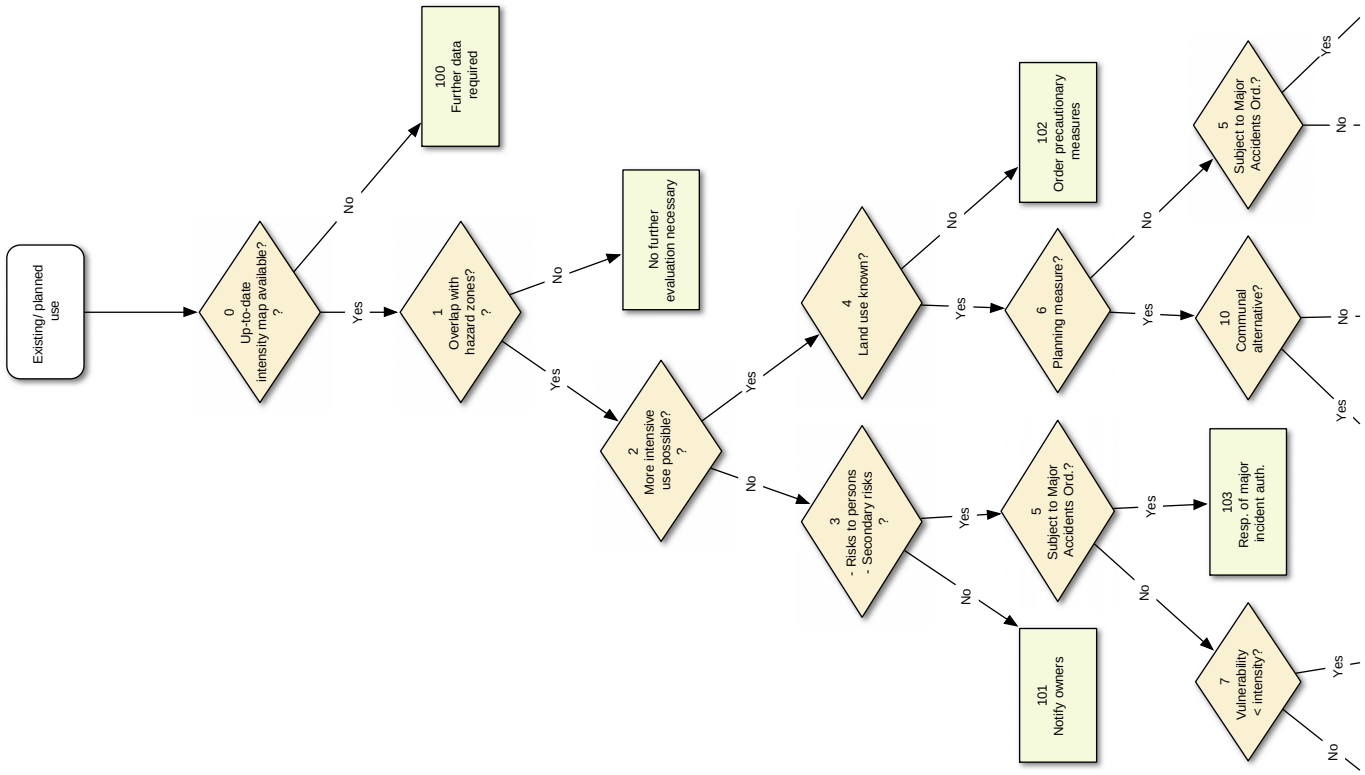
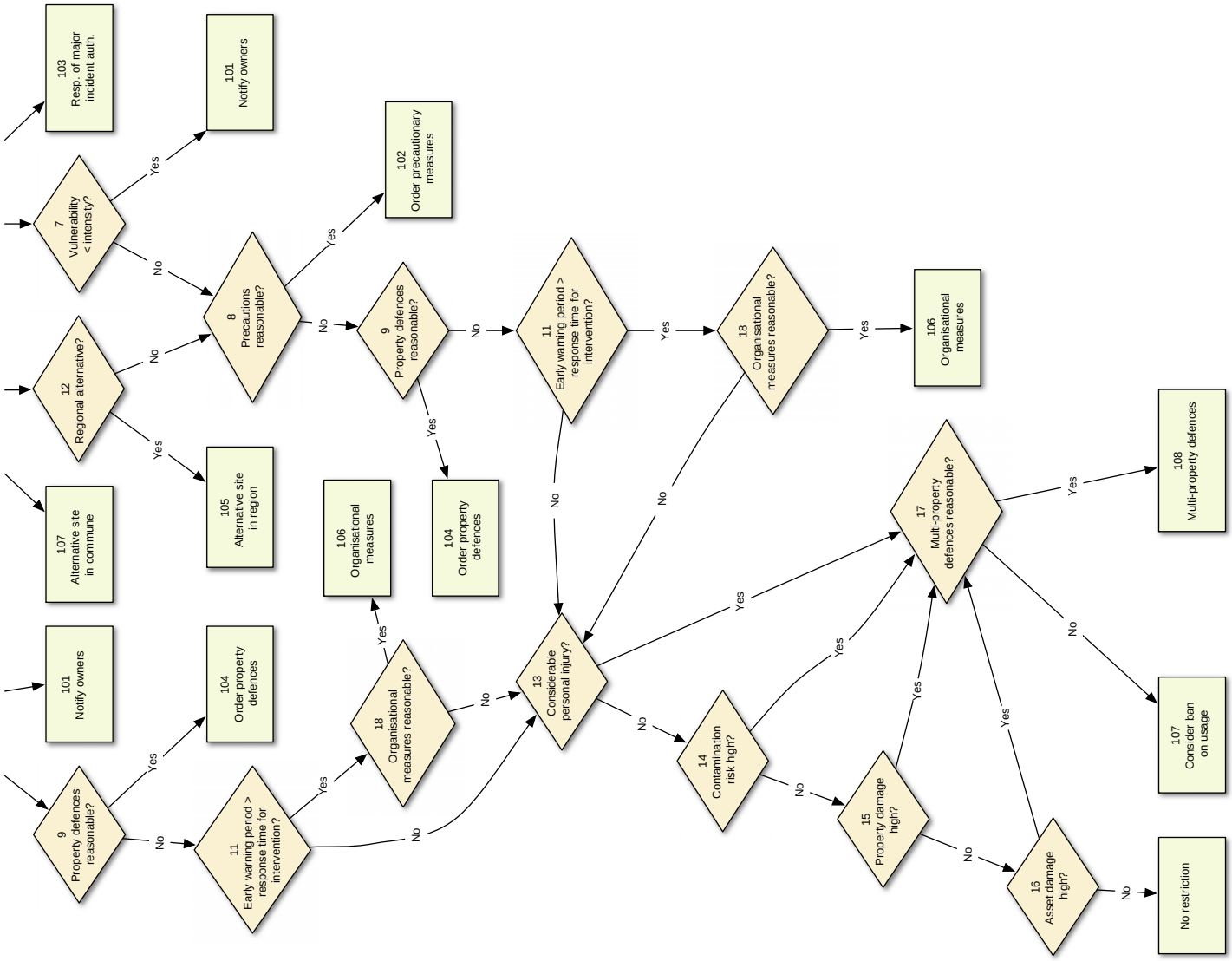


Fig. 10: Decision-making tree derived from case study 2 (Bündner Herrschaft)


103
Resp. of major incident auth.
101
Notify owners
7
Vulnerability < intensity?
Yes
No
102
Order precautionary measures
8
Precautions reasonable?
No
9
Property defences reasonable?
No
11
Early warning period > response time for intervention?
Yes
18
Organisational measures reasonable?
Yes
106
Organisational measures
12
Regional alternative?
No
Yes
107
Alternative site in commune
105
Alternative site in region
Yes
104
Order property defences
No
101
Notify owners
9
Property defences reasonable?
Yes
No
104
Order property defences
11
Early warning period > response time for intervention?
Yes
No
18
Organisational measures reasonable?
Yes
106
Organisational measures
No
13
Considerable personal injury?
Yes
No
17
Multi-property defences reasonable?
Yes
108
Multi-property defences
No
107
Consider ban on usage
14
Contamination risk high?
Yes
No
15
Property damage high?
Yes
No
16
Asset damage high?
Yes
No
No restriction

A2 Key questions (checklist)

Questions on spatial planning scope

- Is the measure concerned spatial planning-related (e.g. inclusion of an area in a particular zone, or changes to the zone plan), or one which is being implemented under the present legally valid zone plan? Depending on the situation, the competent authority will have a different degree of scope.
- How important is the land usage? Is there an overriding interest (regional, cantonal, federal) at play? If so, has the site in question been determined in a relevant spatial planning instrument, such as regional structural plan, agglomeration programme, cantonal structural plan, cantonal strategy or sectoral plan at federal level?

Questions on current or planned land use

- Is the actual land usage known? If it is not yet known, what uses does the law permit at the site in question?
- Is the land use tied to that particular site?

Questions on data and documentation on natural hazards

- Do you have the most important data and documents – such as hazard and intensity maps – that required to evaluate the natural hazard situation?
- Has a strategy for defence measures been drawn up? What measures are planned in the area in question?
- Is the maintenance and thus the effectiveness of the defence measures assured for the long term?

Questions on the hazard and on the extent of damage that might affect usage

- What hazard processes are involved? What processes/events occur in isolation? Which tend to occur in combination? Are there any additional hazards (ground water, surface runoff, etc.)? What secondary risks exist, e.g. incidents or malfunctions?
- Is there any advance warning period? How long is it? Is the hazard a seasonal one? What measures are realistic should an event occur (include first responders in deliberations)?
- What level of uncertainty is attached to the evaluation of the process or the effectiveness of defence measures?
- What effect does the planned land use have on the hazard process?

- What protected objects (people and property; see PLANAT 2013, Fig. 3) are affected? How heavily? How easily can they be regenerated? What particular risks are associated with the land use, such as risks to people in outside areas, or environmental damage from oil tanks? Are the risk bearers aware of the risk? Which risks are of public interest?
- What effect do possible defence measures have on the risks, especially on the residual risk over a long time horizon?

Questions on the formulation of spatial planning measures

- Do the measures limit new risk? Is that risk bearable for those who must actually carry it?
- Will the measures reduce any existing risk in the medium to long term?
- Are there any synergies or conflicting objectives in relation to other areas?
- Does planning and other action make the residual risk and the chosen measures bearable, proportionate, and reasonable? Do the relevant actors agree?
- Have alternatives (e.g. at other locations) been explored?
- Do the measures result in the risks being shifted in the long term to neighbouring plots or areas? Might it be possible to design measures that protect several properties at once?
- Are the owners willing to implement the existing measures, or is the public sector able to enforce them by legal means?
- Is compliance with usage conditions checked?
- What synergies exist with measures taken by third parties, such as insurance companies?
- Do the measures raise awareness about dealing with risks? Are those concerned conscious of the risks, or will defences result in a medium-term increase in risk, albeit of a different nature (less frequent, but on a greater scale)?

A3 Glossary

Agglomeration programme	An agglomeration programme is a planning instrument that permits cross-sectoral issues to be coordinated within a given agglomeration. It rests on horizontal (between partners within the agglomeration) and vertical (Confederation, canton, agglomeration) cooperation. Its purpose is to provide an effective framework for coordinating projects and their implementation in Switzerland's agglomerations.
Building zone	A building zone is a type of land use zone covering land which is suitable for development and which is either largely developed, or is likely to be required and the necessary infrastructure built within 15 years.
Sudden hazard process	Generally high-intensity processes such as avalanches, rockslides or shallow landslides with little advance warning, which present a considerable hazard to both people and material assets.
Dynamic flooding	Flooding caused by fast-flowing water, often with little advance warning. Considerable hazard to people and assets.
Basic development	Basic development refers to the establishment of the basic infrastructures required for land to be used, i.e. roads, public transport, water, waste water, gas, electricity and communications. Sufficient basic development must have been done before the land can be built on (i.e. developed in the traditional sense).
Hazard	A condition, situation or process which can result in injury to persons, or damage to the environment and/or material goods.
Gradual hazard process	Processes such as flooding on the banks of lakes or major rivers in flat areas, involving low flow rates and long advance warning periods. They present a considerable hazard to material assets, in particular.
Land use plan (zone plan)	A spatial planning instrument which determines the permitted use of land – purpose, location and dimensions – for each individual plot. It is binding on the land-owner.
Property defence	Protection for real property (building or facility) afforded by construction measures, either on or immediately adjacent to the property.
Threat level	A hazard referring very specifically to a certain situation or a certain property.
Structural plan	A spatial planning instrument describing the action that must be taken to achieve the target use of space. It provides a coordination framework that is binding on the authorities concerned. A distinction is made between cantonal, regional and communal structural plans.
Risk	The extent and probability of occurrence of damage. Typical indicators include the average annual damage and the level of damage for certain recurrence periods.
Risk evaluation	Process used to assess the information obtained from a risk analysis to evaluate the acceptability of the risk on the basis of personal and collective criteria.

Risk management	Process used to change the level of risk.
Risk bearer	Persons and institutions whose personal and financial resources bear the cost of the damage that may occur as the result of natural hazards. Direct bearers of risk include building owners and users, as well as land-owners, insurance companies, public authorities and the operators of infrastructure.
Potential damage	Extent of the possible damage in the hazard area being studied.
Protected object	Assets and valuables for which risk is to be limited to an acceptable level.
Defence measures	Measures to reduce risk to an acceptable level, or to maintain the level of security that has been achieved.
Special land use plan	A spatial planning instrument that is binding on the land-owner. It is similar to a land use plan, but even more detailed, so that building projects can be subjected to specific regulations. It may also be referred to as a site layout plan, development regulations, development plan or site plan. In contrast to the general land use plan, special land use plans apply only to specific sites.
Static flooding	Flooding caused by slow-flowing water, often with a long period of advance warning. Little hazard for persons, but material assets are at risk.
Floodwater level	The depth of water in the event of a flood. It is measured against the property concerned.
Rezoning	Rezoning is a change in the land use zone allocation for a particular property. It may also refer to the redrawing of planning boundaries to include a property within a building zone, or turning a building zone as per Spatial Planning Act rules into an agricultural or protected zone.