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Risk reduction partnerships in railway transport infrastructure in an alpine environment

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ABSTRACT

The transport sector is crucial for the functioning of modern societies and their economic welfares. However, it is vulnerable to natural hazards since damage and disturbances appear recurrently. Risk management of transport infrastructure is a complex task that usually involves various stakeholders from the public and private sector. Related scientific knowledge, however, is limited so far. Therefore, this paper presents detailed information on the risk management of the Austrian railway operator gathered through literature studies, in interviews, meetings and workshops. The findings reveal three decision making levels of risk reduction: 1) a superordinate level for the negotiation of frameworks and guidelines, 2) a regional to local level for the planning and implementation of structural measures and 3) a regional to local level for non-structural risk reduction measures and emergency management. On each of these levels, multi-sectoral partnerships exist that aim at reducing the risk to railway infrastructure. Chosen partnerships are evaluated applying the Capital Approach Framework and some collaborations are analyzed considering the flood and landslide events in June 2013. The evaluation reveals that the risk management of the railway operator and its partners has been successful, but there is still potential for enhancement. Difficulties are seen for instance in obtaining continuity of employees and organizational structures which can affect personal contacts and mutual trust and might hamper sharing data and experiences. Altogether, the case reveals the importance of multi-sectoral partnerships that are seen as a crucial element of risk management in the Sendai Framework for Disaster Risk Reduction 2015–2030.

1. Introduction

Transportation systems such as railway networks facilitate the fast movement of passengers and freight and are crucial for societal and economic welfare. An essential part of modern societies, it is expected by the general public that transport systems operate at all times reliably [31]. For railway networks, an isolated event can lead to the disruption of all traffic in this railway section [8]. Cascading and fundamental indirect effects resulting in economic losses are possible [70]. Furthermore, the railway companies have to ensure the safety of passengers and personnel and the investments for risk reduction measures should pay-off.

However, hazard management for railway transportation is a challenging task not least due to the significant network susceptibility for a variety of man-made (e.g. car-train crashes at railway crossings [20]) and natural impacts. For example, railway infrastructure elements like tracks, substructures, overhead-components, tunnels and bridges are exceedingly prone to extreme weather events and their consequences such as flooding, avalanches, debris flows, heavy precipitation, storms and heat/cold waves. Ludvigsen and Klaeboe [44] investigated the impact of extreme weather on the freight railway transportation in Finland using the harsh winter in 2010 as an example. The study revealed that around 60% of train delays could be attributed to unfavorable weather conditions (e.g. low temperatures, long-lasting snowfall) and/or weather-related damage to the network. The authors argue that, although risk managers and logistics experts are generally aware of potential impacts of extreme weather, effective mitigation strategies and tools are scarce.

During the 2013 flood in Central Europe, the German Railways recorded heavy structural damage as well as more than 75 track section

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closures and interferences in the German railway network as a consequence of track inundation, track under-washing and mudslides [6]. Hence, in addition to substantial cleaning and repair costs to overcome structural damage of the railway network, the flood impacts also led to significant indirect damage in the form of long-lasting service disruptions along major railway connections, such as the 5-month disruption of the Berlin-Hannover high-speed rail line [6]. Further potential railway infrastructure damage and/or service disruptions caused by natural events include e.g. precipitation- or drought-induced embankment failures [6,16], tree fall-related railway blockage or damage to overhead lines [7], rail buckling due to heat waves [22] and heavy snowfall leading to failures of traction motors, electronic equipment or switch points.

In alpine countries, the situation is particularly challenging since railway lines are important to access lateral valleys and they are essential for European transit [2,72], while the mountainous topography challenges the planning and management of railway transport by various alpine hazards. Besides, many railway lines follow rivers in valleys as the only economically reasonably track option in steep terrains and are therefore threatened being inundated or washed out due to extreme precipitation and flooding. Railway infrastructure and operation, for instance in Austria, has been repeatedly impacted by alpine hazards and (river) floods [24]. High financial losses are the consequence such as EUR 41.1 million following the 100-year flood along the Morava and EUR 75 million due to the flood event and several debris flows in 2013 [38,54]. In addition, if traffic networks are (temporarily) disrupted, alternative options for transportation are rarely available in these mountainous regions [2]. In some cases, natural hazards even caused fatalities and injuries. For instance, a debris flow event in Vorarlberg caused several coaches of an intercity train to derail in 1995. Three people were killed and 17 people were seriously injured [3]. Thus, natural hazard management is a crucial task for the Austrian railway operator ÖBB Infrastruktur AG (in the following: ÖBB), which is focused on in this paper.

In general, impacts of natural hazards on railway transportation are relevant on three different levels [48]: 1) direct losses, i.e. damaged or destroyed parts of the railway infrastructure, such as bridges, stations, railway lines, due to the physical impact of the hazard process, 2) restrictions or complete disruption of the regular service such as speed limits or emergency routing and 3) long-term effects such as loss of customers or a decline of their satisfaction with the service. Compared with other sectors, the scientific literature on the impacts of natural hazard events on transportation infrastructure in general and on railway assets in particular is still limited [47]. The World Bank [73] identifies a dearth of information on how to minimize damage and consequences of natural hazards on transport infrastructure. While most of the existing studies in this field investigate direct and indirect losses, there is only little knowledge on the long-term effects of natural hazards on railway transportation [48]. The focus in the literature is on risk assessment or on documenting and accounting losses due to natural hazards [23,26,36,38,42,43]. Besides, several research projects were conducted in Austria focusing on the detection and early warning for natural hazards concerning railway infrastructure (for details see [13]) as well as related to hazard mapping and contingency planning (see www.monitor2.org). Insights into complex natural hazards risk management of infrastructure elements is still scattered and mostly found in grey literature.

In terms of natural hazards management, Adams et al. [3,42] highlight that communication and collaboration between different stakeholders is of high importance in order to reduce risks from natural hazards in the transport sector. Doll et al. [24] conclude that one priority of adapting the transport sector to extreme weather events should be given to strengthen vertical and horizontal information channels between authorities, the transport industry and their customers' ([24], 82). Partnerships between the railway operators with fire brigades and other emergency services are seen as crucial for the reduction of natural hazard impacts. Next to this, cooperation between railway and weather forecast providers are recommended in order to establish reliable weather warning systems [3,24,33]. Quinn et al. [58] propose, inter alia, to work together with 'stakeholders, suppliers, passenger and freight user groups' (64) as well as to link up with experts e.g. in transport planning and various environmental sciences such as meteorology, hydrology and geology.

The existing reports indicate that risk management in this sector is complex and thus not manageable by a single entity alone. Instead, there is a need to engage in multi-sectoral partnerships to effectively and efficiently manage the risks from natural hazards. The request and necessity for partnerships in the transportation sector is reflected by the more general recommendation in the UN Sendai Framework for Disaster Risk Reduction 2015–2030 [71] to enhance multi-sector partnerships in risk management. However, little is known about the value, implementation and procedures within such partnership in general. In particular, no comprehensive overview of risk management of railway operators at different levels (in alpine surroundings) exists to date.

To address the current gap in research, this paper investigates the multi-sectoral risk reduction partnerships between a railway operator, namely the ÖBB, and various further stakeholders across different sectors. Such multi-sectoral risk reduction partnerships consider the needs of different sectors in the face of risk events, including different perspectives on risk management. They are defined as: 'voluntary but enforceable commitments between public authorities, private enterprises and civil society organizations across sectors. They can be temporary or long-lasting. They are founded on principles of sharing the same goal in order to reduce risks and gain mutual benefit' ([46], 13). These partnerships are not a panacea for risk management. They need to be effective and thus, it is important to know when their management actions make sense and when governance aspects should be improved and how.

To assess the effectiveness and strengths of multi-sectoral risk reduction partnerships and to identify potential limits in their performance, we will use the Capital Approach Framework (CAF) ([46], see Section 3). The main idea behind this kind of analytical framework is to identify the weaknesses and strengths of multisectoral partnerships. The CAF analyses the risk governance performance of multisectoral partnerships by giving special attention to its capabilities to face a particular risk [19].

Three levels of natural hazard and risk management were distinguished – one mainly federal level and two regional to local levels (see Section 4.1). On all three levels, there are various partnerships of which we present selected ones and evaluate them. For the partnerships on regional to local levels we also assess how certain partnerships worked or even emerged under the stress test of floods and landslides in June 2013. The following questions guide the analysis:

1. Which risk reduction partnerships can be identified at different levels regarding the railway infrastructure in Austria?
2. How can these partnerships be characterized with regard to their capitals?
3. Which suggestions for further enhancement of these partnerships can be derived from the characterization?

The remainder of this article is structured as follows: In the second chapter we give comprehensive background information on the natural hazard situation affecting the Austrian railways and the responsibilities on railway risk management in Austria in order to better understand the findings. The third chapter introduces the theoretical approach (CAF) and the methods used to assess the capitals. In the fourth chapter the results are presented including information on the three decision levels of ÖBB's risk management (4.1) and their evaluation using the CAF (4.2). The findings are discussed in detail in chapter 5 and recommendations for further progress in the risk management of the

Austrian railways and beyond are given and conclusions are drawn in chapter 6.

2. Natural hazards affecting the Austrian railways and their management

2.1. Natural hazards and the damaging event in June 2013

About 65% of the national territory of the Republic of Austria is located in the Eastern Alps and thus shows a harsh mountainous nature with limited space for urban development and infrastructure [57]. As a result, railway infrastructure and operation have been repeatedly affected by alpine hazards. Out of 6000 km of railway tracks in Austria, 1500 km are vulnerable to natural hazards [59]. Between 1990 and 2011, about 1200 weather events such as heavy precipitation, storms or heat waves caused damage to infrastructure in a direct or indirect way [37]. In the future, this number could further increase due to the effect of climate change on critical meteorological conditions that cause damage to railway infrastructure [37].

In June 2013, an especially severe hazard event with floods and debris flows affected the core railway. Unusual amounts of rainfall (up to 300 mm in some parts of Austria) occurred along the northern Alps and resulted in combination with already highly saturated soils due to an exceptionally wet May to destructive debris flows, heavy landslides and floods. The middle and western parts of Austria were impacted the worst. Gauges along the river Danube and some other large rivers climaxed to a discharge of more than a one hundred years return period [9]. Heavy thunderstorms that followed the extreme rainfall events caused many torrents, debris flows and mudslides. Thankfully, no train passengers or personnel were harmed, yet physical impacts on the railway tracks were significant. In total, there were three derailments and track closures at 20 different track sites which lasted in some cases even longer than several weeks [35]. The Western railway line was severely affected by several torrents and landslides e.g. at the community Taxenbach (see Fig. 1) and was closed for two weeks. It was impossible for several days to travel from Vienna to Innsbruck and further on to Switzerland, because both possible track lines (the so-called 'German corridor line' between Salzburg and Kufstein and the line via Zell am See) had to be closed (see Fig. 1a). These damages (see Fig. 1b and d) made new constructions necessary (see Fig. 1c and e).

The most devastating event for ÖBB was a torrential debris flow which flushed away a whole railway bridge. Furthermore, the fine material transported by the torrent was deposited up to two meters of height within a nearby tunnel. This tunnel is over 400 m long and the debris was transported to the other end (see Fig. 1b). The cost to construct a new overflow structure (see Fig. 1c) was alone estimated to EUR 4.5 million [53].

Nationwide, the event in June 2013 led to EUR 75 million of estimated costs for repair and reconstruction of tracks [54]. In case of such exceptionally high losses from natural disasters, subsidies[1] can be increased upon request of the ÖBB as was done in 2013 [55]. Hence in December 2013, subsidies by the Austrian state were enlarged by EUR 17.5 million for inspections, maintenance and repair works [55].

2.2. Natural hazard management of ÖBB

Risk analysis and management are important issues for the ÖBB which have a long history as for example in case of avalanche management along the Arlberg railway which is carried out since its construction in the 1880s [60]. According to Austrian legislation, ÖBB is responsible for the construction, financing, operation and maintenance of the core railway as well as for relevant protection measures against natural hazards [25]. In order to fulfill the latter task, ÖBB maintained from 2005 to 2014 a Department of Natural Hazard Management, which merged in 2015 together with other entities into the department of 'Geotechnics and Natural Hazard Management'. Even if a systematic comparison of natural hazard management in the railway sector of different states is missing, it can be stated that the existence of a department on issues such as natural risk reduction is exceptional in Europe (I1).[2]

In general, ÖBB's natural hazard management follows the risk management cycle including prevention, provision, preparedness, rescue/recovery and documentation/reflection. The general aim is an anticipatory, proactive approach, i.e. to prevent adverse impacts of natural hazards instead of having to react to them. Next to the importance of structural protection measures also communication (e.g. alarm plans), analyses (e.g. hazard or vulnerability maps) and information e.g. on weather situations are seen as crucial to achieve this aim [40]. For example, ÖBB started a standardized hazard and vulnerability mapping including the whole railway infrastructure in 2007. This mapping combines information on the infrastructure elements themselves, their maintenance standard and their exposure to various natural hazards. This approach is proactive and supports the planning and prioritizing of preventive measures [52]. Furthermore, ÖBB owns meteorological stations and operates a weather warning system called infra:wetter, which was mainly developed after the flood in 2005 [41]. Within the project 'Adaptation of Railway Infrastructure to Climate Change', infra:wetter was presented as a best practice example and pioneer work on the field of weather warning and weather information for railway operator [52]. Next to this, the ÖBB Department of Natural Hazard Management improved the documentation of damage on railway infrastructure, a practice which is still uncommon in many other European countries [37].

ÖBB's combination of structural and nonstructural measures corresponds with the general approach in hazard management in the European Alps. Likewise, the general shift to a risk-based approach, which has been increasingly recommended since the 1990s, is reflected in ÖBB's strategies on risk management (see [27] for more detailed information on developments in hazard management in Austria).

To address the risk posed by natural hazards, the railway operator provides relevant resources for natural hazard management and is approved to take its own decisions as a company. However, it always operates within a wider institutional framework and a complex situation of alpine hazards. Therefore, the risk management within the railway transportation in Austria cannot be handled by ÖBB employees alone and risk mitigation measures in the transportation sector have to be aligned with public risk management strategies in many places. Thus, partnerships and vital cooperation between various stakeholders at different administrative levels are needed.

2.3. Natural hazard management in Austria

In Austria, the legislation concerning natural hazards is diverse as 'no uniform and consistent text of law with respect to the protection from the effects arising from natural hazards is given' ([29], 524). The competences concerning natural hazards are divided along different sectors (e.g. finances, environment) and specific natural hazards. In case of floods the Austrian Waterway Administration is responsible for the rivers Danube, March and Thaya and the Flood Control Management (BWV) is in charge for all further rivers. For torrents and all other alpine hazards, the Torrent and Avalanche Control (WLV) is responsible

[1] The large costs for maintaining and operating the railway system cannot be generated entirely on the market or through rail user charges (Infrastrukturbenützerentgelt) [14]. Therefore, ÖBB receives annual subsidies from the federal government for the operation and the provision of services as well as for the maintenance and repair of the railway network in accordance with § 42 (1) and (2) of the 'Federal Railway Law' [25].

[2] This refers to the interviews in Appendix 1.

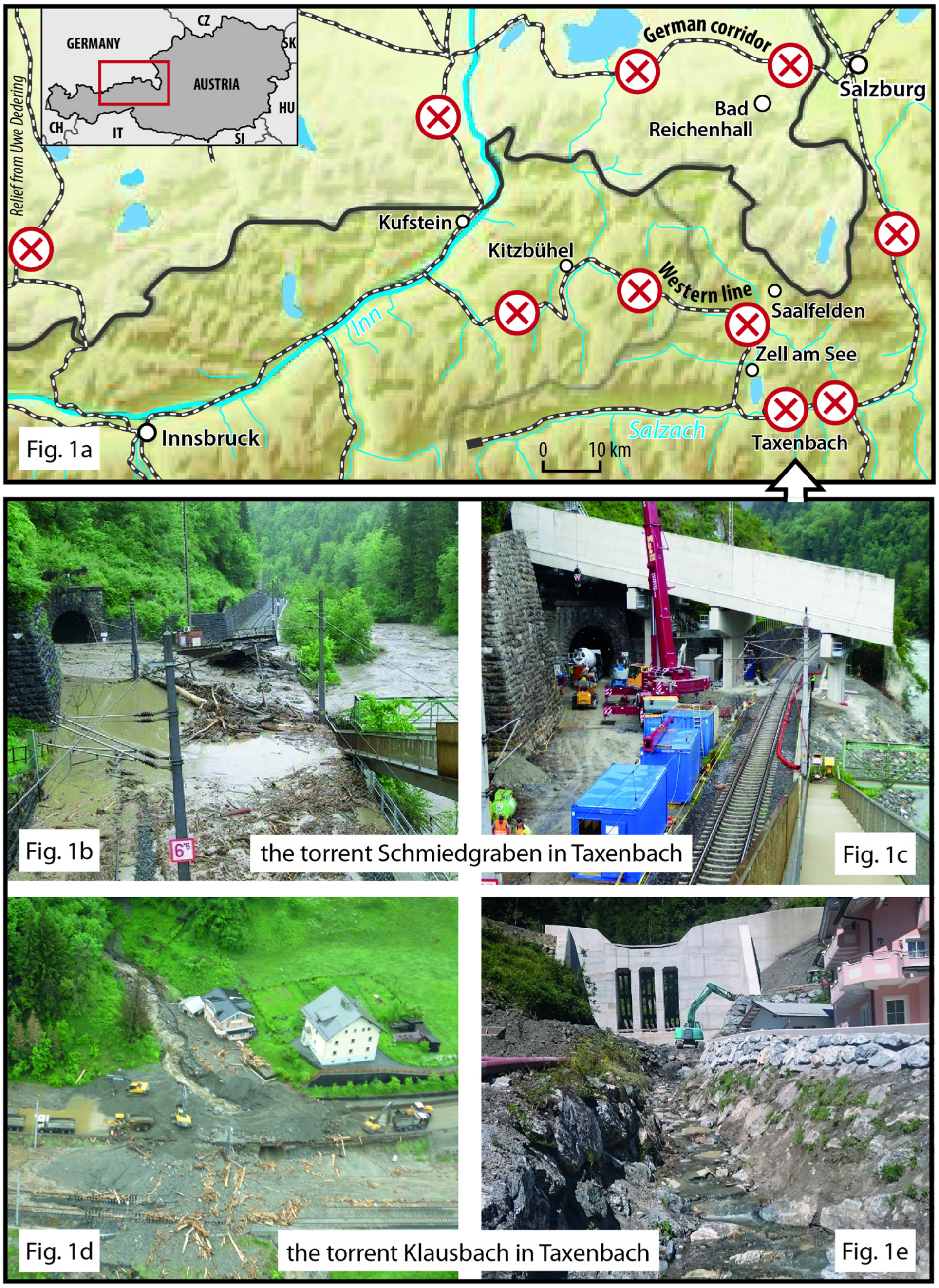

Fig. 1. Damage due to torrents and landslides in June 2013 in Taxenbach and structural risk reduction measures constructed afterwards at these locations. 1a) Map of disrupted railway tracks in the affected region (crosses = locations of disruptions). 1b) A debris flow at the Schmiedgraben destroyed a railway track and affected a tunnel. 1c) Structural risk reduction measure at the Schmiedgraben constructed after the event and financed by ÖBB. 1d) Railway track and houses affected by a debris flow at the Klausbach torrent. 1e) Structural risk reduction measure at the Klausbach planned and implemented in a partnership under the lead of Torrent and Avalanche Control. Sources: 1a) Data of disruption provided by ÖBB. 1b) and 1c) Photos provided by ÖBB. 1d) and 1e) Photos provided by WLV Pinzgau; own compilation.

[69]. In addition, and due to the federal system of Austria, competencies are divided along different vertical administrative levels [61] with the regional and local level managing the major part [32]. Next to European and national laws, there are numerous regulations, approaches and responsibilities within the nine federal states (see for an overview [62]) which are not harmonized with each other [68].

As in many other countries, there is the trend to re-arrange roles in the field of disaster management and especially flood risk management. The central government hands work and responsibilities towards the local level and the level of individual households (e.g. [17,51]). This increases the need of interactions between a variety of actors (including in some cases railway operators) [68,69]. There are still some unresolved challenges for sufficient inter-local co-operation as Thaler et al. [68] show applying the concept of proximity (spatial, institutional, social, technological and relational proximity between the stakeholders).

Against this background, it becomes obvious that there is a quite complex risk management situation with a multitude of competent authorities and potential cooperation partners in this field. In case of the railway operator this is even complicated by the huge railway network which necessitates ÖBB to collaborate on multiple levels (from the European to local level), to partner with different expert institutions for all alpine hazards and for floods in all nine federal states and in case of riverine floods to represent and balance the interests from downstream as well as upstream areas. Having the importance of a safe and uninterrupted railroad service in mind, it becomes crucial to achieve an overview of ÖBB's risk management and to better understand and evaluate related multi-sectoral risk reduction partnerships. This serves as a basis for recommendations how to enhance the risk management and can be useful also for other stakeholders in the transport sector and beyond.

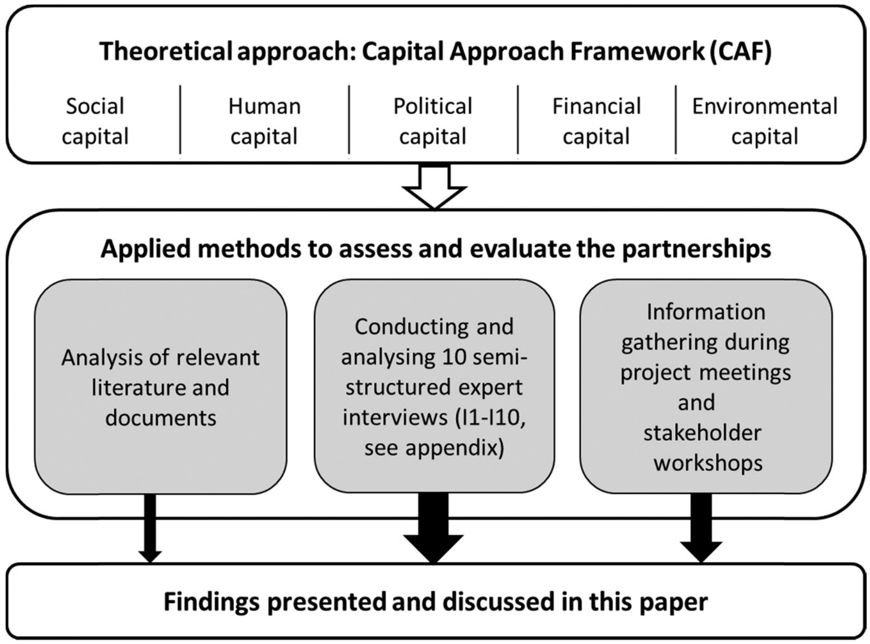

Fig. 2. Overview of the research design. Source: own illustration.

3. Research design: theoretical approach and methods applied

In order to characterize and evaluate the partnerships of ÖBB's risk management, the CAF was applied. While other analytical frameworks (as actor-network analysis or principal component analysis) are basically focusing on the relational aspects of the system, the CAF focusses on analyzing the governance performance of the risk management governance structures and by doing so identifies strengths and weaknesses of the risk governance structure [18].

The CAF is based on the Capital Theory Approach [28,64,66], the Capital Approach to Sustainability [4,21,67] and the Capability Approach [64]. In old-established economics literature, two capitals dominated: the financial capital and the physical capital. Later on, the analysis of human capital [39], social capital or cultural capital (dating back to [15]) gained importance. Serageldin and Steer [65] affirmed that we need to recognize at least four categories of stocks (human-made or fabricated, natural, human and social). Bebbington [5] proposed five capitals (produced, natural, social, cultural and human). Goodwin [28] also differentiates between five capitals, but these include financial, social, human, natural and man-made. The same five capitals are considered by the OECD [56] as well. The later were used for the development of the CAF with some modifications and including inputs from the sustainable livelihood approach proposed by Scoones [63].

The sustainable livelihood approach gives an individual examination of different forms of capitals needed as the support of wealth and well-being. The principle of sustainability is important to the CAF, because the concept of sustainability is supposed to permanently ensure the essential characteristics of a regenerative and natural system [75]. The linkage of capitals to sustainability has the aim 'to leave the next generation the same amount and composition of capitals we found' ([65], 31). The CAF is based on this idea for achieving an effective governance performance, taking five capitals into account that should ensure the good and effective functioning of multi-sectoral risk reduction partnerships today and in the future. The CAF integrates five capitals to analyze governance performance: social, human, political, financial and environmental capital. These five capitals reflect capacities of the governance structures to be able to react to extreme or hazardous events [18,19]:

a) Social capital focuses on relations(-ships), networks, shared norms and values that qualify and quantify social interactions.
b) Human capital provides information on individual skills and knowledge. It includes social and personal competencies, knowledge we gather from formal or informal learning, the ability to increase personal well-being and to produce economic value.
c) Political capital focuses on the governmental processes, which are performed by persons who have a political mandate to enact policy. It also includes laws, rules and norms which are juristic outcomes from policy work. In contrast to many other approaches, the CAF includes the political capital.
d) Financial capital involves all types of wealth (funds, substitutions etc.) that are provided, as well as financial resources that are bounded in economic systems, production infrastructure as well as banking industries.
e) Environmental capital comprehends goods and values that are related to land, environment or natural resources.

The generic framework can be adapted to different conditions and geographies, in this paper to natural hazard management within railway transportation in alpine environments. Typically, the CAF is applied in a two-step procedure: It starts with guided interviews of stakeholders of the respective case study, in which indicators for every factor of the CAF will be developed. After summing up all results from the different stakeholders, a validation workshop is conducted that shows the final governance performance of the case studied (e.g. [19]). In our study, we followed a similar approach and applied three approaches (see Fig. 2): 1) literature research and document analysis, 2) semi-structured interviews, and 3) information gathering during project meetings and stakeholder workshops.

First, relevant literature and further documents (workshop proceedings, presentations or project reports) were analyzed. Second, ten semi-structured expert interviews were conducted with ÖBB employees and different core partners in natural hazard and risk reduction at national and regional levels in 2013 and 2014 (see Appendix 1). The interviews addressed the stakeholders' tasks within the natural hazard management system as well as various issues of their partnerships in general and with ÖBB's Natural Hazard Management Department in particular. Using a content analysis, the relevant aspects regarding the

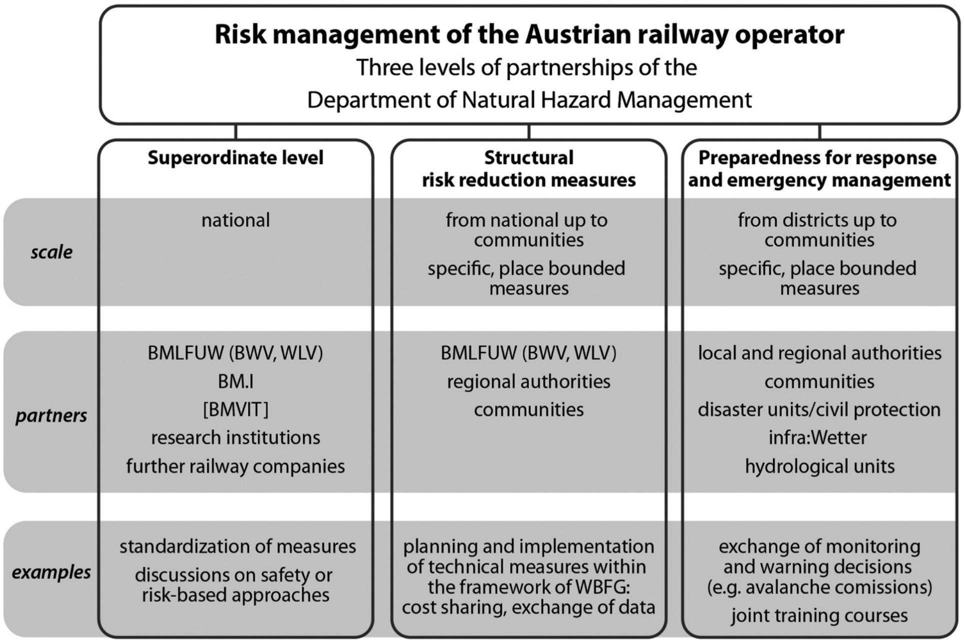

Fig. 3. Cooperation on three decision-making levels; Source: own illustration. (BMLFUW = Federal Ministry of Agriculture, Forestry, Environment and Water Management, BWV = Flood Control Management; WLV = Torrent and Avalanche Control; BM.I = Federal Ministry of the Interior; BMVIT = Federal Ministry of Transport, Innovation and Technology; WBFG = Hydraulic Engineering Assistance Act) (The names and responsibilities of these entities refer to the status during the research phase (2013–2015). Later changes are not considered in the text and illustration; e.g. the BMLFUW was restructured and named BMNT (Federal Ministry for Sustainability and Tourism) in 2018.

research questions were derived from the transcribed interviews. The stakeholders were able to comment on preliminary results, but no changes were requested. Third, there were several meetings with ÖBB representatives between 2013 and 2016. A few meetings were recorded and transcribed, but in most of them notes were taken. The findings from the semi-structured interviews were presented and discussed with the railway operator. There was a workshop in September 2015, in which results were discussed with representatives of ÖBB and further members of the risk reduction partnerships.

Finally, the governance performance of different partnerships on three decision levels was evaluated on the basis of the CAF by integrating all information from the literature review, the interviews as well as the meetings and workshops (see Fig. 2). The gathered qualitative data were interpreted and translated into a classification and evaluation scheme (see Table 1). So, issues which are seen as (very) well performed in all the compiled data are classified as +. Parameters which led to some criticism or modification requests, but are perceived as working out fair enough in general are graded +/−. Matters which are desired, but missing or which are the subject of (major) criticism are categorized as −. Thus, the method can be described as an aggregated self-assessment. Evaluative information could not be compiled for every aspect on all three decision-making levels, e.g. because not all issues are relevant for all partnerships as can be observed especially in the field of financial capital with specific regulations on each decision-making level.

4. Findings: characterizing and evaluating risk reduction partnerships

4.1. Three levels of partnerships regarding risk management

Three levels of natural hazard and risk management were identified, each with different kinds of partnerships (see Fig. 3).

4.1.1. The superordinate level

On the superordinate level, the partnerships concern discussions and decisions in legislation and technical standards. Therefore, it mainly involves the natural hazard management of ÖBB and Federal Ministries. The 'Ministry of Agriculture, Forestry, Environment and Water Management' (BMLFUW) is the most important partner for ÖBB staff at this level. Especially the ministerial sections 'Flood Control Management' (BWV) in the Water Department, which is responsible for the protection against floods, and the 'Torrent and Avalanche Control' (WLV) in the Forest Department, which focuses on alpine hazards, play a vital role (see Fig. 3; I4; I5). Next to the BMLFUW, the ÖBB has relations to the 'Federal Ministry of the Interior' (BM.I) that is responsible for civil protection, crisis and disaster management (I6). In principle, cooperation with the 'Federal Ministry of Transport, Innovation and Technology' (BMVIT) is self-evident [61], but did not play a big role in the risk reduction partnerships at the time of the interviews. Next to these partnerships with different ministry units there are cooperation with research institutions and other railway companies in national and international research projects.

An example for cooperation at the superordinate level is the discussion between the Austrian Standard Institute, ÖBB and WLV on how to plan, construct, maintain and inspect protective structures against avalanches, rockfalls and torrential hazards. The standardization of technical protection measures avoids ambiguity, e.g. in case of lawsuits (I1; I5).[3] A further example is the debate on the application of safety-based or risk-based approaches in natural hazard management. The safety-based approach cannot be applied comprehensively because there are only limited resources for protection measures. This contradicts the desire for safety which is rather high and still growing within the population, while risk acceptance has decreased [29,61]. Thus, discussions have been taken place, in which the representatives of ÖBB and the BMLFUW have been involved.

4.1.2. The level of structural risk reduction measures

When it comes to the planning and implementation of specific measures at a certain place, partnerships are based on risk analyses including on-site inspections and risk assessments with prioritizations. The partnerships on structural measures thus deal with the design, implementation and maintenance of structural protection measures. ÖBB is mainly responsible itself for constructing and maintaining protective measures [25,61] unless the planned measures also protect settlements, roads or energy supply. In the latter cases, cooperation with WLV or BWV, regional authorities or communities takes place and the protection system can be subsidized according to the Hydraulic

[3] The standards known as ONR 24800 became effective in 2013 and were introduced in conjoint seminars (I1; I5).

Table 1
Characterizing the capitals for selected partnerships. Evaluation: + Existent and works out very well; +/− Partly existent and works out but there are some challenges; − Not existent or does not really work out.

Capitals and characteristics	Evaluation of partnerships on three decision levels		
	Superordinate level – partnership of ÖBB and BMLFUW (I1; I4; I5; I6)	Structural risk reduction level – partnership of ÖBB and BMLFUW (I1; I2; I3; I4; I5; I7; I9)	Preparedness of response and emergency management – partnership of ÖBB's regional units and the Disaster Unit Salzburg (I1; I2; I3; I7; I8)
Social capital			
Common goals	+	+/−	+/–
Knowing the persons in charge	+/–	+	+
Personal (direct) contacts	+/–	+/–	+
Reliability, trust and mutuality	+	+	+
Human capital			
Long continuity in work teams, long-term employees	–	+/–	+/–
Expert knowledge	+/–	+	+
Exchange of knowledge	+	+/–	+
Exchange of data	+/–	+/–	+/–
Taking part in research projects	+	Research projects on this level not known	Research projects on this level not known
Common knowledge through common studies	No evaluative information available	+	+
Political capital			
Clarity of legal situation and multitude competences	+/−	+/−	+/−
Enshrining and applying risk-based approaches	–	No evaluative information available	–
Standardized approaches of implementing structural measures	Not relevant	+/−	Not relevant
Financial capital			
Applying the Hydraulic Engineering Assistance Act (WBFG)	Not relevant	+/−	Not relevant
Cost-efficient decision for precautionary and organizational instead of structural measures	Not relevant	Not relevant	+
Minimize costs by joint usage of survey points	Not relevant	Not relevant	+
Environmental capital			
Research on climate change and adaptation	+/−	Research projects on this level not known	Research projects on this level not known
Control structures affect the environment.	Not relevant	No evaluative information gathered	Not relevant

Engineering Assistance Act [74].[4]

In these cases, the federal government and the federal states support protective measures by a specific share – dependent on specific measures and field of subsidy [74]. This share is covered by the Disaster Fund which finances the public share of preventive measures and covers losses due to natural disasters in Austria [29]. The remaining costs are shared between the stakeholders that benefit from the measure such as communities or the railway operator who has to pay its share from its core budget. Thus, the focus of the partnerships on structural measures is on information and cost sharing in order to plan and implement engineering works. Cooperation in this realm takes place from national (e.g. financing) down to the local level (planning with experts and municipalities). It includes formal, standardized procedures regulated in the WBFG as well as informal negotiations, in which the particular financial burdens of the different stakeholders benefitting are determined (I1; I4; I5).

4.1.3. The level of preparedness for response and emergency management

The ability to prevent natural hazards by means of structural protection measures, such as dikes or avalanche protection, is considerably limited in the Alpine environment due to the sheer number of torrents and avalanche paths and financial constraints. Besides, structural protection measures are always designed for events with a certain return period and hence residual risks remain. Therefore, precautionary and organizational risk reduction measures play a vital role and include monitoring of hazards, disseminating warnings and alerts and deciding on reduction of speed or track closure. ÖBB has its own operative units, which have comprehensive knowledge of the tracks, check risks and carry out repair work to regain service availability in a short time (I1). Next to this, there are diverse formal and informal collaborations between ÖBB employees and further stakeholders who are very site-specific since the Austrian federal states manage cooperation in case of an event in diverse ways and the regions in Austria are prone to different natural hazards (I1). Therefore, we illustrate this risk management level using two examples: the risk management of a section of the so-called Western railway located in the federal state of Salzburg (see Fig. 3) and the evolving partnerships around the weather monitoring and early warning system called infra:wetter.

The cooperation in the Salzburg region includes the jointly use and maintenance of survey points for avalanches, joint inspections of torrents and rocks, a common risk analysis for a part of the Western railway line and close personal contacts between responsible persons of the state of Salzburg and the ÖBB (I2; I3; I7). A further important cooperation are integrated training courses on avalanches organized by the Disaster Control Salzburg, in which ÖBB employees have taken part (I7). In case of floods, warnings are given by the hydrological services of the federal state (I8). In this cooperation, mostly information and data are shared or assessed jointly. The motivation of such collaborations can be seen in costs minimization, in development of common understandings of structures and terminology and in getting more comprehensive information as basis for decision-making. However, the

[4] Within this law, it is regulated that the WLV has to conduct a detailed cost-benefit-analysis if project costs exceed 1 million Euros. For projects with lower costs, analyses are simplified [10].

decisions for certain non-structural measures such as precautionary and organizational risk reduction measures are finally taken by the ÖBB itself. Commissions (not individuals) within the ÖBB are responsible in case of avalanches and it is considered broadening this approach to other hazards such as floods and torrents as well. The main reason why commissions are preferred for decision taking is liability exclusion. This includes on the one hand that decision-making moves from an individual to a team level and on the other hand that there is a formal liability exclusion for certain decisions in the corresponding regulations (I1).

The weather monitoring and early warning system infra:wetter, which covers the entire railway network, is jointly operated by ÖBB and a private weather service. It also uses information from the federal meteorological weather service (ZAMG). Infra:wetter is among other things used to identify so-called critical meteorological conditions 72 h in advance. The latter are weather conditions that potentially lead to larger disruptions of train traffic and thus require coordinated action by ÖBB [37]. This early information and warning time support organizational countermeasures such as observing the vulnerable spots, advanced closing of specific tracks and evacuation of affected areas [41]. Infra:wetter originally started as a contractual business relation between ÖBB and the private company, but is increasingly evolving into a multi-sectoral partnership, as also other partners get involved (see Section 4.2.3).

4.2. Characterization of selected risk reduction partnerships using the Capital Approach Framework (CAF)

The CAF shaped by the five capitals is used to assess the multi-sectoral risk reduction partnerships of the Austrian railway operator on three levels. Table 1 gives an overview of the findings and evaluations.

4.2.1. The superordinate level

With regard to the superordinate level, the characterization of risk reduction partnerships focusses on the cooperation between ÖBB's Department of Natural Hazard Management and the BMLFUW which includes the WLV and the BWV (see Fig. 3). Table 1 summarizes the evaluation regarding the five capitals. The partnerships were characterized as very intense and were based on personal contacts as well as on institutionalized meetings.

According to our interview partners (I1; I4; I5), the social capital is formed in the first line by common goals, knowledge of the persons in charge as well as reliability, trust and mutuality in cooperation. The natural hazard management group within ÖBB was seen as a very reliable partner (I1; I4; I5). A crucial facet of working successfully together is the personal contact and knowing each other well which enables trust and, at the same time, makes it possible to contact the person in charge directly.

Nevertheless, personal contact and knowing the persons in charge can be quite challenging. Regarding human capital, partners of ÖBB perceive past restructurings within the railway company as a difficulty because long-lasting, successful partnerships often work better with long-term employment continuation of staff and organizational units. Although there was an improvement and more continuity for two or three years before the interviews were conducted (I5), this was still perceived as a big challenge. At last, regarding the partnerships with the BMLFUW knowledge is often shared by the partners, but data exchange should be fostered (I4; I5).

With regard to the political capital, a complex legal situation due to various laws concerning natural hazard management can be ascertained. Thus, people need to have expert knowledge in order to make sound decisions. The responsible ÖBB person as well as the BWV criticize that there is a growing desire for safety in the Austrian society and thus residual risks are not well accepted (I1; I4). Yet, even with a large amount of effort, risks can never be completely avoided. Thus, ÖBB's Natural Hazard Management aims at strengthening risk-based approaches and supports the development of a national consensus of risk acceptance. This would present an argumentative and legally effective base for decisions since financial resources for e.g. protection measures are limited. This knowledge could also be referred to in disputes (I1). Further financial aspects are not relevant for the partnership on this level, as every partner receives its own financial resources.

With regard to environmental issues, research on climate change, climate change adaptation and vulnerability to natural hazards is important on this decision-making level in order to strategically integrate relevant knowledge in future planning and to anticipate possible hazard developments and requirements in risk management. ÖBB was part of several research projects in this field[5] and participated in developing the Austrian Strategy for Adaptation to Climate Change (see [12]). However, in order to evaluate the implementation of the recommended climate adaptation measures in the railway sector more specific analyses are needed as the first progress report [11] is too general to allow to draw specific conclusions for ÖBB's risk management.

4.2.2. The regional level of structural risk reduction measures

Table 1 summarizes the evaluation regarding the five capitals concerning structural measures. In case of structural measures, the risk reduction partnerships ground on both, personal contacts and standardized approaches. Regarding the social capital it is important that the partnerships are not open to everyone, but only to institutions, or municipalities affected by the measure. The main goal – protection of people and assets against future events – is shared by all partners but the kind and design of specific structural protection measures as well as the temporal prioritization of measures compared to other projects are in some cases debated on (I9). Crucial factors for successful risk reduction partnerships mentioned by the interview partners are reliability, confidence in partners and mutuality in cooperation (I1; I4; I5).

Relevant for the human capital are the personal contacts between partner institutions as well as broad expertise. Both are encouraged by the fact that there are a number of fellow students from the University of Natural Resources and Life Sciences (BOKU) working in the WLV and ÖBB. Nevertheless, over the last years before the interviews were undertaken there has been concerns among local employees of the WLV that they did not know the responsible staff of the railway operator. Hence, a meeting was organized so that various people in charge at the local/regional level have become acquainted with each other (I5).

Information plays a crucial role in the preparation of protection measures. Shared knowledge between the railway operator and WLV includes information on hazard zones and GIS-data on risk areas (I5). Furthermore, the BWV provides data regarding inundation areas. On this basis, ÖBB was able to undertake a risk assessment which was provided in return to the BWV. It was also mentioned that the broad exchange of relevant data needs further improvement (I1; I4).

In the political sphere, the WBFG is the regulatory framework for planning and implementing structural measures. Despite this transparent background, for some stakeholders it might be challenging to keep track with diverse competences on different scales, in various federal states and for different natural hazards. The arrangements are thus in some cases difficult and time consuming (I1). Therefore, there is the call to further standardize work flows when planning and implementing measures. Different stakeholders expressed the desire that the counterpart informs them earlier and in a more standardized way about planned measures in order to strengthen synergies (I1; I4).

The WBFG regulates that there is a cost sharing, but this needs to be

[5] For example: PARAmount - imProved Accessibility: Reliability and security of Alpine transport infrastructure related to mountainous hazards in a changing climate (http://www.alpine-space.org/2007-2013/projects/projects/detail/PARAmount/show/index-2.html#project_outputs) and ENHANCE - Enhancing risk management partnerships for catastrophic natural hazards in Europe (http://enhanceproject.eu/).

negotiated in each project. The public share is managed by the Natural Disaster Fund, while the ÖBB expenses have to be paid by the railway operator. In these partly time-consuming processes of negotiation, there is always the possibility that some stakeholders might try to get the other stakeholders involved in financing (a bigger share of) the protection measures so that their own share decreases. Therefore, benefits for the transport railway need to be estimated and explained precisely (I1).

Technical protection structures have impacts on the environment. However, the regulation of environmental impacts of structural measures was not evaluated in the interviews. According to the Technical Guidelines for the WLV ecological compatibility needs to be regarded. However, there are possibilities of exceptions if the measures prevail public interests [10]. Two examples of structural measures are shown in the photos in Fig. 1. These were implemented after the severe damages caused by the flood in June 2013. In one severe case, ÖBB was responsible by itself for the structural measure since no other stakeholders were affected at this location (ÖBB, personal comm. 2014; see Fig. 1b; c). In several other cases of debris flows, the community Taxenbach, ÖBB and further stakeholders were affected at the same time (e.g. see Fig. 1d). This has catalyzed the planning and implementation of several protective structures at seven torrents with different kinds of technical measures holding back debris (see e.g. Fig. 1e). All seven protection measures were combined and processed as one project with subprojects. The project has been managed by the WLV and was based on already existing surveys of these torrents and possible structural measures as well as inspections of the situation after the event of 2013 [76]. It reached a very high priority within the scheme of the WLV and a high cost-effectiveness. Besides, the project has been ascribed a high public interest as supra-regional relevant transport facilities such as the Western railway have been included in the protection plans [76]. Already in June/July 2013 the involved stakeholders agreed on different technical measures and the financing of this project. The planned project time span is from 2013 until 2018. The costs of the projects involve EUR 9 million from which 48% has borne by the Republic of Austria (federal level) and the other share is mainly divided between the federal state of Salzburg, the municipality Taxenbach and its water associations, the road administration and ÖBB [76]. ÖBB has a share of about a fifth of the costs. The process of negotiation was perceived as fast and efficient [50]. This was supported by the fact that the different subprojects and their financing were not discussed separately but all measures regarding the seven torrents were negotiated jointly and the regulatory basis for the partnership – the WBFG – was known by all partners and could be applied. Besides, the WLV obtained already information and plans for structural measures for certain sites.

4.2.3. The regional level of preparedness for response and emergency management

The description of the risk reduction partnerships on the level of non-structural measures will also mainly be presented and evaluated for the Salzburg region (Table 1; right column). In general, there seems to be a very vital cooperation between the different public administrations, the local ÖBB staff and further stakeholders (I2; I3; I7; Table 1). Personal contacts as well as knowing and trusting each other are seen as an essential pre-requisite for collaboration. The interviewees mention that there are different interests and goals in the day-to-day work but in case of emergencies they share the goal of minimizing damages and protecting people (I2; I3).

Local knowledge and experiences in the region are regarded of being of high importance in order to evaluate critical situations. Thus, continuity in the organization regarding the employees is necessary, but not easy to achieve (I7). The exchange of knowledge and evaluation information is a vital part of working together on precautionary and organizational measures (I2; I3; I7). There is, for example, the quest for strengthening the exchange of data on meteorology, a common map basis and a shared event data base (I2). Next to this, knowing what kind of information the partner needs at which time is perceived as crucial. This kind of knowledge is striven by common trainings (I8).

The Disaster Relief Law [34] of the federal state of Salzburg and the Railway Act [25] are parts of the regulatory framework for non-structural measures. Next to this, there is a 'Forum Natural Hazards' which was formed in 2007 and brings together different relevant sections regarding natural hazard management in Salzburg. Critical points on this level contain the necessity to strengthen risk-based approaches (I2; I3; I7) and the complexity of competences (I7).

As part of the collaboration, the joint use and standardized maintenance of survey points for avalanches and weather stations is used as a strategy to minimize costs by not having a double monitoring infrastructure by the federal state and ÖBB. Regarding the environmental sphere, no relevant aspects could be identified in this context.

Next to this collaboration in Salzburg, a nationwide partnership on precautionary measures refers to the weather monitoring and warning system infra:wetter. It has only recently evolved from a contractual business relation into a broader partnership as a consequence of the flood in June 2013. Therefore, no evaluation on the five capitals was performed the way it was done for the previous risk reduction partnerships. The first stress test during the large-scale flood of 2013 showed in general that infra:wetter, information exchange and event response worked well.

In general, the negative impacts of the flood event in 2013 could be significantly reduced due to timely preparatory measures. This applied particularly to the protection of human life as a result from imposed speed limits, track closures, close surveillance of rail sections at risk and the evacuation of areas at high risk. Neither passengers nor personnel were harmed, injured or even killed also due to the smooth communication between the ÖBB's Natural Hazard Management and the operating forces in the field. This was regarded a key success factor (stakeholder workshop in Oct. 2015). Still, the flood event of 2013 was also a trigger for the ÖBB to further enhance its strategy of risk management by building up and expanding cooperation with additional external partners from the public sector, university and industry, improving the social and human capital of their risk reduction partnerships. For instance, in case of infra:wetter, the concept of using thresholds for critical meteorological conditions possible affecting railway operations (see [37]) is currently expanded to critical hydrological conditions. In this context, location-specific thresholds for inundation levels posing a risk to railway infrastructure, for instance in the Salzburg region, were defined together with the hydrographic services and integrated into infra:wetter. Based on these thresholds, the hydrographic service of Salzburg can provide railway-specific flood warnings to the ÖBB (stakeholder workshop in Oct. 2015).

To better account for the specific features of the railway network and to improve the level of detailed information, the maps of the Floods Directive were enhanced together with an engineering company by using e.g. a detailed DEM. The resulting maps illustrate inundated areas with return periods of 30, 100 and 300 years and take the specific details of the railway network into account (see [38] for an application). They thus help to create specific flood risk management plans and monitoring as well as support early warning systems.

Next to enhancing and expanding partnerships, ÖBB also modified some aspects in its internal risk and crisis management in order to improve fast communication in emergency situations. During the event in 2013, the need for clearly defined responsibilities became obvious, especially during crisis situations that last for several days and therefore require several staff changes ([35]; stakeholder workshop in Oct. 2015).

5. Discussion

In this paper, the risk reduction partnerships between ÖBB's Natural Hazard Management Department and further stakeholders were analyzed and evaluated by using various information sources as input and the CAF as theoretical framework. In a first research question, it was asked which risk reduction partnerships could be identified at different levels. As illustrated in Fig. 3, the risk management of ÖBB can be divided into three levels: the superordinate level, the level of structural risk reduction measures and the level of preparedness for response and emergency management. The presented overview shows that there is a variety of multi-sectoral risk reduction partnerships with numerous stakeholders on all three levels. The situation of the partnerships in the investigated realm is too diverse to analyze and present them all. Thus, a substantive focus was necessary and limitations needed to be accepted when answering the second research question.

Against this backdrop, the second research question tackles the characterization of a few chosen partnerships with regard to their capitals following the CAF. The importance and characterization of the five capitals varies according to the level of partnerships as different aspects are focused on. However, there are also similarities at various levels (see Table 1 and Section 4.2), such as the importance of the social and human capital. In the following paragraphs, the results of this characterization are summarized, reflected on and – in line with the third research question – further enhancements of the partnerships are suggested.

The social capital can be characterized as fairly positive for all three chosen partnerships. Common goals, personal contact within partnerships and knowledge of people in charge are highlighted as very important by all stakeholders as well as in the literature (e.g. [58,68]). These aspects are existent, but partly need to be strengthened. At the local level, the personal contact might differ remarkably between various regions, e.g. for Salzburg, our case study region, personal contact is perceived as good, but Adams et al. [3] mentioned challenges for their case study region in Tyrol. Further crucial aspects related to social capital are reliability and trust between partners which are given satisfactorily on all three partnership levels. The assessment also showed that there were efforts of ÖBB and its partners to strengthen personal contacts and knowledge of who is in charge by organizing joint meetings. On the basis of this evaluation, the extension of these efforts is suggested as essential for enhancing the social capital and thus efficient risk management.

The professionality and expert knowledge of partners and people involved in the partnerships was found to be a very strong human capital. The flood event in 2013 even initiated further improvements and expansions of collaborations especially in the field of preparedness for response (and recovery). Yet, there is a difficulty to obtain a continuity of employees and organizational structures which can affect personal contacts, knowing and trusting each other and developing expert knowledge. This is seen as a difficulty within the human capital category and is mentioned also by Quinn et al. [58] as a crucial challenge in adapting the railway sector to climate change. It is recommended to encourage long-term organizational units and employment and – as this is not always possible – to support sufficiently long training periods and familiarization time, sufficient employees also on a local level and detailed exchange between former, current and future personnel. Offering exchange possibilities between different partners are even more important after institutional shifts and changes of staff. [58] also suggest to 'engage with educational institutions who train the staff your organization recruits' which could be done by universities.

Another major issue in the category of human capital is a need for suitable data in a very good quality and a need to share information, data and interpretations between partners. This is in line with the results of Adams et al. [3] who state that the exchange of data was given the biggest attention by the stakeholders taking part in the implemented risk reduction dialogue. While in many cases, this exchange works well, in other cases stakeholders are reluctant to share data and knowledge. In sum, on all levels and by diverse stakeholders there is a call to improve and in some cases to standardize the practice of data and knowledge exchange. A first step to improve data exchange is to analyze the underlying reasons for reluctance which can include high expenses for data generation, lack of trust or lack of knowledge of needs and existent data. Furthermore, railways as such belong to the critical infrastructure. Therefore, certain data and information must have a limited access for safety/security issues. These various causes need specific answers and approaches such as strategies of joint usage and financing options, improvements in mutual trust and discussions on which data could be shared without violating safety rules. To reach better data exchange, it is necessary that partners communicate intensively about their existent and desired data in terms of content, formats, quality, storage and updating. Going beyond the analyzed partnerships, the Austrian Strategy for Adaptation to Climate Change (see [12]) lists the development of a nationwide consistent damage register for all transport infrastructures as one measure. In order to achieve such a register, broader collaboration between various transport operators, BMFLUW and BMVIT seems necessary.

For the political capital there are still some challenges. One major challenge is to gain a clear picture on the relevant legislation and complex competences in multi-sectoral and multi-level governance public administration ([29,61,69]; see Section 2.3). In case of the railway operator the situation is even more complicated due to the huge rail network which makes it impossible for the company to be in direct contact with all communities and stakeholders along the railway system. Despite past efforts to clarify the complex situation [1], further simplifications or at least extensive coordination e.g. between different federal states are desired. Next to this, the knowledge and understanding of the situation needs to be improved e.g. by long-lasting experiences or specific (joint) trainings. As another point, it is of interest how current developments of catchment-wide co-operations in flood risk management [69] add to or change the governance situation and which role ÖBB can play in some of these co-operations as a stakeholder which operates in downstream as well as in upstream areas.

A further aspect of political capital is that accepting residual risks is seen as an important basis for risk management but runs counter to the desire for safety and an 'increasing demand for zero risk' [29] in the general public. In their case study on risk management for transportation, Adams et al. [3] also mention risk-based approaches as demanded by the stakeholders. Thus, recommendations need to reach beyond the presented partnership. The awareness of hazards and (residual) risks needs to be increased within the general public by custom-fit information and consultation. Next to this, it was proposed that the Austrian loss compensation and risk transfer system needs modification as it does not take risk-aware and risk-minimizing behavior into account [29]. Doll et al. [24] underline that risk information such as risk maps need to be considered when planning future railway infrastructure. The consideration of flood risk in planning processes of supranational transportation lines needs to be addressed at the European level.

Characteristics of the financial capital are especially important on the level of structural risk reduction measures since financial options, i.e. cost sharing issues, form the core of these partnerships. The stakeholders taking part in these partnerships are the ones affected by a specific hazard situation such as communities, water boards and/or infrastructure operators (railway and highway operator or energy suppliers) as well as the federal government and the federal state subsidizing the measure within the WBFG. Many of the advantages and disadvantages listed in the literature of participatory planning (e.g. [30,45]) can also be found in some of these diverse negotiation processes. Positive aspects are for example, that various interests are combined, the project design is improved and – as a specific for these negotiations – cost-sharing is agreed on. Stated criticism for some cases involves that they are too time-consuming or that stakeholders are reluctant to take their share. A comparison of various, either successful or critical evaluated cases could support the improvement of these processes.

At the level of preparedness for response financial issues were positively evaluated and were further expanded in the aftermath of the 2013-event. Here, the fact that survey points and weather stations can be used jointly and thus costs can be minimized was mentioned as an important achievement. This also demonstrates the potential benefits of partnerships, i.e. sharing of resources, especially when funds are limited.

The environmental capital did not play an important role in the risk reduction partnerships across the different levels. Research on climate change and adaptation was only mentioned at the superior level, but not in respect to structural measures and preparedness and response at the regional level. As the local level plays an important role in risk reduction, research involving also these risk reducing partnerships could be enhanced. While structural measures can have an impact on the environment, this seemed to be no issue due to existing legislation regulating their implementation. Moreover, natural resources themselves play an important role in natural hazards management in Austria, such as protective forests. Maintaining this protection by natural resources seems especially important given the projected increase in climatic hazards due to climate change [38]. Protection forests were, so far, not on the agenda within the presented risk reduction partnerships, because the ÖBB maintains own protection forests [49]. However, with increasing temperatures and altered water budgets, the vulnerability of current tree species and according changes might become an issue. Thus, it is advisable to establish future collaboration on this topic e.g. with the help of research projects.

Regarding the empirical approach, the analysis revealed that the CAF is appropriate to illuminate strengths and challenges of a risk management system. As with empirical studies in general, the analysis is only as good as the information and data one can gather. In the presented case this depends on the openness of the involved stakeholders and their willingness to share also critical aspects. This is anything but natural regarding sensitive topics such as safety issues and companies' information. The triangulation of approaches such as interviews and workshops prove to be beneficial in order to reach an understanding of the complex situation of risk management. The direct interaction with the stakeholders on the ground helps to validate the results by discussing them and leads to broad recognition of determined weaknesses and critical aspects. This in turn might increase the stakeholders' motivation to work on improvements and enhance resilience.

6. Conclusion

The aims of this paper were to better understand the risk governance in the railway sector, to assess the strengths and challenges of existent risk reduction partnerships and to suggest enhancements, using the risk management of the Austrian railway as an example. In sum, our evaluation draws a positive picture of ÖBB's risk reduction management and its partnerships. The application of the CAF approach showed that especially the social and human capitals were considered as crucial for a successful partnership. Both capitals were evaluated mostly positively at the different levels of risk reduction partnerships. A challenge that was identified is to ensure stability of these important capitals (e.g. personal contacts, reliability, data exchange and expert knowledge) within large organizations and a complex risk management environment. Therefore, education and training, recruitment processes, but also networking events that enable exchange of experiences and introduction of new personnel play a key role to keep the partnerships alive and beneficial. Future comparative research could focus on how different railway operators – or even stakeholders from other sectors – manage this issue.

From the assessment, it becomes clear that establishing a dedicated unit for natural hazards management within the ÖBB was a successful mean to enhance stable personal contacts with relevant partners, trust, reliability, and to secure required expert knowledge. Although this study does not provide a comparative analysis of different governance forms, it suggests that an own department responsible for natural hazards management provides several advantages for a railway operator. For instance, competencies are more obvious and contacts as well exchange between employees should be easier. Thus, arrangements might be taken faster, information and knowledge e.g. on processes or practical issues can be shared more easily and therefore, loss of knowledge can be better avoided in cases employees leave the company. Furthermore, an own department underscores the relevance of the topic and can support the position of risk reduction management in internal and external discussions and negotiations. Given the positive evaluation, also other railway operators that face a risk from natural hazards should consider to set-up such a dedicated unit.

Moreover, our analysis and also other findings [52,58] highlight the benefits of engaging in a partnership with meteorological services. Such a partnership is the basis for many emergency measures, especially in a mountainous environment, where the deployment of structural measures is limited.

Another challenge that remains, which is not unique to a railway operator, is the desire of the public for safety on the one hand and the fact that full safety cannot be achieved on the other hand. Therefore, future research could pay attention to the cooperation between the railway operator and the customers (passengers). While this was not the focus of the present paper, it is mentioned as an important aspect in the literature (e.g. [24,33,58]).

In this article, we provide a first comprehensive overview of the risk management partnerships of a railway operator. Future research and comparisons between different railway operators and their governance structures could further help to identify best practices which is important for the implementation of the Sendai Frameworks for Disaster Risk Reduction.

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Conflict of interest

The authors declare that they have no conflict of interest.

Appendix 1. Overview of conducted interviews

#	With whom? – Representative of…	Where?	Remarks
I1	ÖBB Department of Natural Hazard Management; Several employees in the head office	Vienna	
I2	ÖBB Department of Natural Hazard Management; Local employee 1	Salzburg	together with interview 3, 7
I3	ÖBB Department of Natural Hazard Management; Local employee 2	Salzburg	together with interview 2, 7
I4	Flood Control Management (BWV)	Vienna	
I5	Torrent and Avalanche Control (WLV)	Vienna	
I6	Federal Ministry of the Interior' (BM.I)	–	by telephone
I7	Disaster Unit (Salzburg)	Salzburg	together with interview 2, 3
I8	Water Management, Flood Control (Salzburg)	Salzburg	
I9	Disaster Unit (Lower Austria)	Tulln	
I10	Hydrology (Lower Austria); Employee 1	St. Pölten	together with interview 11
I11	Hydrology (Lower Austria); Employee 2	St. Pölten	together with interview 10
I12	Torrent and Avalanche Control (WLV)	Vienna	
I13	Torrent and Avalanche Control (WLV), Section Salzburg	Zell am See	

Note: Interviews 1–11 were conducted by the first author in September and October 2013. Interviews 12 and 13 were conducted by Robert Kirnbauer in March 2014.

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