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16th TO EARLY 18th CENTURY PROACTIVE COPING WITH NATURAL HAZARDS IN SLOVENIAN ALPS AND THEIR SURROUNDINGS: WITH LESSONS FOR THE FUTURE

Abstract: The paper presents strategies of coping with natural hazards in Slovenian Alps and their surroundings from the 16th to the early 18th century. The efficiency of presented institutional coping strategies is addressed as well. Results make clear that historical adaptation to the discussed hazards was a gradual process. The following possible contributions of environmental history of observed early modern hazards to a better prepared, more adapted future are identified: (1) identification of hazard prone areas, (2) better estimation of magnitude of hazards with long return periods, and (3) learning form (un)successful historical practices of coping with natural hazards.

Key words: *environmental history, early modern period, mountains, floods, landslides, avalanches*

INTRODUCTION

Recently, several studies have focused on strategies of coping with natural hazards in mountainous and hilly parts of Central Europe in 16th to early 18th centuries (esp. Rohr 2007, 2012 and 2013, Pfister 2011 and literature listed there, Scherer 2011, Schenk 2012). Many aspects of institutional strategies of coping with natural hazards in Slovenian territory and in its surroundings at that time have been discussed too (Fresacher 1965 a, b, Zwitter 2014 b, 2015 a, 2017; floods in sub-Pannonian part of present-day Slovenia: Golec 2014, Radovanovič 2006, upgraded by Zwitter 2017; the main contribution of Rohr 2014 to the early modern issues is the presentation of the locust hazard). Zwitter (2015 c) combined various types of sources to discuss the influence of 17th century environmental change on mountain farms, including agricultural coping strategies which will not be repeated here. The major 1511 earthquake was last studied by the historian Košir and the seismologist Cecić (2011). The possibilities of learning from 16th to early 18th century

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natural disasters and coping strategies for a more resilient and better prepared future have been discussed especially by Pavšek (2000), Rohr (2009), Pfister (2011), Kjeldsen *et al.* (2014), Raška and Brázdil (2015), and Winiwarter *et al.* (2016). The aims of this paper are (1) to present new results from archival records in the context of existing knowledge on coping strategies[1], and (2) to provide further examples of possibilities of learning from experienced natural hazards in the past and from historical coping strategies for a better future hazard preparedness in Alpine parts of present-day Slovenia and its surroundings.

MATERIALS AND METHODS

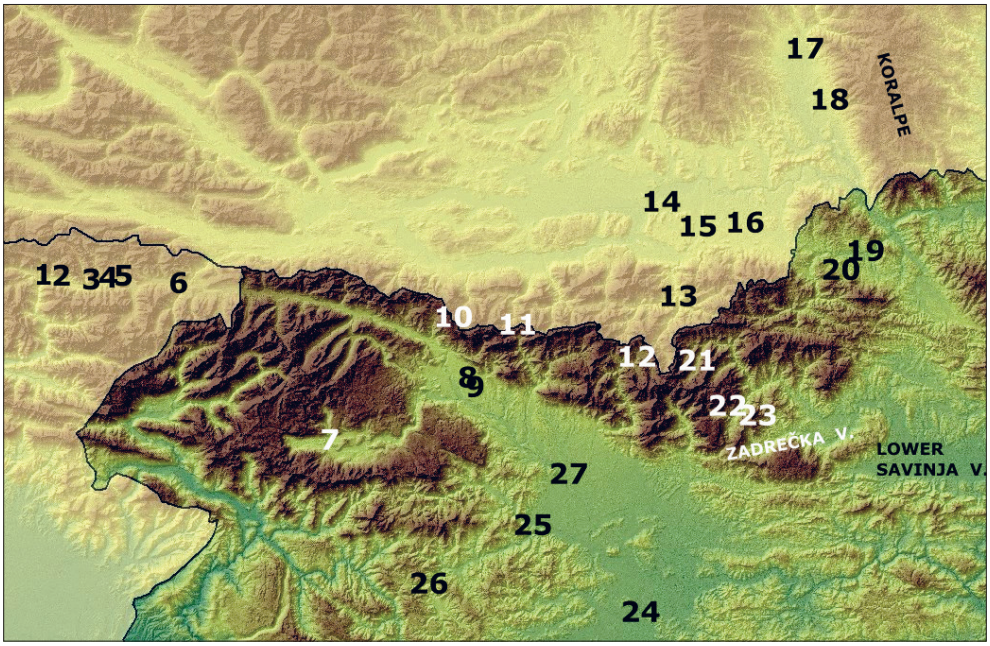
New results are based on investigation of records from a part of the archive of the estates of the province of Carinthia, preserved in the Archives of the Province of Carinthia, on an analysis of the chronicle of the parish of Solčava, preserved in the parish archives in Nova Štifta, as well as on a combination of field work and the first detailed cadastral data, kept in the Archives of the Republic of Slovenia. Written sources were analysed using historical critical method (cf. Winiwarter 2016).

RESULTS AND DISCUSSION

1. INSTITUTIONAL COPING STRATEGIES

The majority of people in the observed time lived in the countryside as subjects of seigneuries, delivering dues to the seigneuries and taxes to the province/state. Seigneuries took various measures after holdings of tenants were affected by natural hazards. (1) They could enable a recuperation of the economic power of a holding, e. g. by permitting the subject to convert a part of the common (pasture/forest) into fields as a compensation for the plots lost due to erosion; in this way adaptation to flood hazard affected also flood-safe locations. (2) If the economic conditions of affected holdings did not improve, burdens of the subjects could be reduced (Zwitter 2014 b, 2015 a). (3) Seigneuries acted as creditors of the subjects, especially through toleration of arrears in delivering the dues; the delays could extend over more than a year (Zwitter 2015 a, c). (4) They could allow subjects affected by a natural hazard or disaster to pawn or sell a part of the holding in order to get the means, but in this way, the holding of the tenant was at least temporarily reduced. (5) Exceptionally, a seigneury helped the affected subject with goods, e. g. cereals, and did not expect them to be returned. Only some of these measures were carried out in a certain part of a single seigneury at a certain moment and coping strategies could differ also on the same territory and within the seigneury in the course of time. In some cases, seigneuries required preventive measures, e. g. works in the stream bed to be taken in order to approve the relief to the subjects affected by natural hazards (Zwitter 2015 a). Seigneuries did not always take

[1] I shall not discuss material reactions as responses to the opinion that disasters were a result of God's punishment for sins (see Juneja, Mauelshagen 2007).



Picture 1: Locations, mentioned in the text. Key: 1 — Pontebba/Ponteibe/Tablja/Pontafel, 2 — San Leopoldo/La Glesie/Lipalja vas/Leopoldskirchen, 3 — Santa Caterina/Sante Caterine/Šenkatrija/Sankt Kathrein, 4 — Malborghetto/Malborghet/Naborjet/Malburgeth, 5 — Ugovizza/Ugovize/Ukve/Uggowitz, 6 — Tarvisio/Tarvis/Trbiž/Tarvis, 7 — Stara Fužina, 8 — Vrba, Hraše, 9 — Hlebce, 10 — Belščica, 11 — Ljubelj/Loibl, 12 — Jezersko, 13 — (Eisen)Kappel/(Železna) Kapla, 14 — Stein/Kamen, Seidendorf/Ždinja vas, Piskertschach/Piskrče, 15 — Gösselsdorf/Goselna vas, 16 — Traundorf/Strpna vas, 17 — Wolfsberg, 18 — Gemmersdorf, Paierdorf, Obereberndorf, 19 — Gutenstein/Guštanj (Ravne), 20 — farm Pečnik (Kot pri Prevaljah), 21 — farm Plesnik (Logarska valley), 22 — farm Planinšek, 23 — St. Leonard's church, 24 — Ljubljana/Laibach, 25 — (Škofja) Loka/(Bischof)Lack, 26 — Fužine, 27 — Kranj/Krainburg. For easier orientation, boundaries are represented in their present-day outline. Background: Large Relief Map of Slovenia.

the measures about which the subjects were informed that they would be taken, at least not on time. In 1670 s one of the subjects of the seigneury of Gornji Grad from the upper Zadrečka Valley (see Picture 1) complained about not having received the promised financial support by the seigneury after the devastation of the pasture and forest in his possession during a flood event (Valentinitsch 1974).

The system of institutional coping was different in princely seigneuries and princely urban settlements. It included cooperation of the state, the regional and local level and in some cases enabled effective coping strategies. This system to a certain degree functioned in the late 15th century already (Žontar 1966, Orožen 1971) but in 1540 s it was probably still not firmly established (Zwitter 2017). From 1564 to the early 18th century, applications for a relief to disaster affected people arrived from local level to Graz (now SE Austria) (Zwitter 2015 a), where princely central authorities for Alpine parts of present-day Slovenia were located at that time (Spreitzhofer

et al. 1988). The court in Graz was quite distant from Slovenian Alps. In order not to depend only on the probably exaggerated report from the affected territory and also to know, how to react, the court treasury as the central authority for administration of princely possessions asked the *viztum*, i. e. its regional representative, to provide another report on this natural disaster, including also a recommendation, which measures the court should take. A good example is the confirmation of a one-year tax relief to the flood-affected market town Gutenstein/Guštanj (Ravne; see Picture 1, no 19), situated in an Alpine valley, in 1573, on condition that the capital, which would otherwise have been needed for the tax, would be invested in works in the riverbed to prevent a similar devastation in the future (Zwitter 2015 a) — an interesting but not exceptional decision for the time (cf. Rohr 2012, Schenk 2012). Cooperation of authorities at different levels took time, so this system did not enable to react in the emergency phase of those disasters, which lasted for a short time. *Viztum*'s recommendations, which measures to take, were only in some cases acceptable for the court in Graz. Otherwise the court either asked the *viztum* to propose another, more acceptable form of relief, or the authorities in Graz simply did not follow the recommendations from the regional level (Zwitter 2015 a).

Coping strategies in seigneuries and by central authorities could be activated in the case of natural hazards causing long-term devastation (e. g. during flood events) but also short-term damage (e. g. bad cereal harvests) (Zwitter 2015 a).

In those seigneuries, which were not princely, the administrative system of estates of provinces was in charge of administration of taxes, which were based on revenues from land in possession of tenants. It was involved also in tax reliefs after natural disasters (Zwitter 2015 a), however, such systems of relief by estates of provinces are less investigated than the system in princely territories.

Estates of provinces were also responsible for reductions of taxes delivered by *free peasants*[2]. In early June 1660 heavy rain caused floods in many places in the northern, central and southern part of Lavanttal (i. e. valley to the west of the Koralpe on Picture 1; KLA 1662/63 a). On 7 June rain triggered also a mudflow from the Koralpe down the bed of the Gemmersdorfer Bach (Fresacher 1965 a), which devastated buildings and plots of land in possession of inhabitants from at least three villages — Obereberndorf[3], Gemmersdorf and Paierdorf (KLA 1662/63 a; see Picture 1, no 18). At least 29 people died (Fresacher 1965 a), some buildings collapsed, among them the house and at least some of the outbuildings of a free peasant, and a part of the church in Gemmersdorf. Many plots of agricultural land — among

[2] Peasants with seigneurial rights to a certain source of agrarian income, e. g. those exempt from obligations to the seigneury because they bought personal freedom as well as freedom of their holdings and, consequently, only had to deliver taxes to the province (Vilfan 1980).

[3] The majority of this village is at present situated north of Gemmersdorf, where buildings were erected on the former agricultural land. According to the early 19th century data, Obereberndorf lay to the east of Gemmersdorf (Kärnten Atlas — Darstellung — Kartenhintergrund — Franziszeischer Kataster, about 1820), thus a mudflow affected this village before it reached Gemmersdorf.

them a considerable share of fields and meadows of the free peasant — were eroded or covered by deposition, including huge rocks; one of them allegedly weighed about 170 tons (Fresacher 1965 a, KLA 1662/63 a). The free peasant asked the administrative system of the estates of the province for a tax relief. The responsible official had to provide a report on this event, which confirmed the statements of the free peasant. The estates doubted the reliability of both sources. 2,5 years after the mudflow, they ordered another report from a court close to the site of the disaster. Due to its purpose the report focused on the damage caused to the free peasant and included even an unusually precise drawing. In January 1663, the representative of the authority of the estates of the province[4] ordered the responsible official to act. The taxes of the free peasant were reduced by a bit more than ⅓ for as long as it would not be possible to cultivate the devastated land again (Fresacher 1965 a).

Tax reliefs and preventive interventions in the landscape connected with these reliefs, were not the only way of material strategies of institutional coping with natural hazards. In towns, urban institutions acted also e. g. through the influence on trade in cereals after harvest failures to prevent scarcity. The town Kranj/Krainburg (Picture 1, no 27) assured supplies in cereals during some events of scarcity (Žontar 1982 [1939]). In the 16th century, the town counsel of the princely town Ljubljana/Laibach (Picture 1, no 24) — the capital of the province, thus relevant also for inhabitants of Alpine territories — at least sometimes allowed peasants from the SW of the province of Carniola, and also from the province of Gorizia and the territory of Trieste, who were involved in the bilateral trade between the warmer territories closer to the Adriatic and the (sub)alpine/continental interior, selling salt, olive oil and wine, to buy cereals in Ljubljana — even when amounts of cereals, allowed to be sold to burghers of Ljubljana, were limited because there were too few as a consequence of harvest failures. In the 17th century, at the latest, foreigners involved in the mentioned bilateral trade, e. g. those from the province of Gorizia and the territory of Trieste, were not allowed to buy cereals at weekly messes in Ljubljana, when due to bad harvests, which caused scarcity, locals (except for bakers) only had the right to buy limited quantities of grain. This measure enabled town authorities not only to assure better food supplies for locals, but also to prevent a further increase in cereal prices because of a limited demand. In the second half of the century importance of trade in cereals in Ljubljana changed — cereals bought in Ljubljana were at that time mainly consumed in the town, export of grain through Ljubljana became exceptional (Valenčič 1977, Gestrin 1991). In the town (Škofja) Loka/(Bischof)lack, situated in the contact zone between the pre-Alpine hills and the Ljubljana basin (Picture 1, no 25), trade in cereals functioned in a different way. The seigneury of Škofja Loka, whose lord was at the same time the lord of this town, stored pretty large quantities of cereals obtained as dues or tithes in its two granaries — the bigger one was located in the town. The seigneury had a monopoly on cereal trade in the town whenever it was possible to buy cereals in

[4] Explanation of the function of "Burggraf" in Carinthia according to Spreitzhofer et al. 1988.

its granary, i. e. in those months when highest cereals prices were expected. Consequently, in case of a bad harvest the granary in Škofja Loka opened later than usually, because the price was expected to rise. The majority of these cereals was sold to burghers of Škofja Loka and capitalists from pre-Alpine ironworks in that seigneury, who were not allowed to buy cereals elsewhere (Blaznik 1973). Some burghers active in early capitalist forms of production in the countryside were also engaged in adaptations to natural hazards. E. g., a burgher of the town Škofja Loka, who owned almost half of the important ironworks Fužine in the Poljanska Valley (Picture 1, no 26), built in 1549, contributed a major part to the sum needed for reparation of this ironworks after the 1565 flood; in a couple of years the ironworks were again fully operable (Blaznik 1973, Gestrin 1991).

Coping with natural hazards through influence on trade existed also at a higher territorial level. The example of the province of Carniola makes clear that export of cereals was many times prohibited due to harvest failures in the 16th and the first half of the 17th century; in the first half of the 17th century at the latest, cereals were in such cases imported to Carniola, which could at that time usually export some cereals — especially wheat. However, bans on export of cereals did not stop the entire cereal export. On the one hand, some grain was exported illegally, on the other hand, not exceptionally permissions were issued for grain export to specified areas despite the general prohibition. The situation changed in the second half of the 17th century when export of cereals from Carniola became exceptional, probably due to an increased demand, thus import of grain to the province became more frequent, but was still rare. Cereals were imported regularly from the early 18th century on, thus also grain prices became less dependent on the harvest in Carniola (Valenčič 1977, Gestrin 1991).

Other institutions which were not rarely included in material coping with natural hazards in the observed time include various courts (see Spreitzhofer *et al.* 1988). In the following subchapter two such case studies are presented.

1. 1. Territorial dispersion of seigneuries — only in some cases a successfully faced challenge

A study of late 16th to early 18th century flood risk management in a part of the Alpine basin Jezersko (Picture 1, no 12), based on sources of the court of one seigneury, proves profound anthropogenic interventions in beds of Alpine streams, which significantly altered the flood hazard. A brook, flowing from the mountains, was in the bottom of the basin directed into an artificial channel in the late 16th or early 17th century. The curve of the man-made channel was not properly constructed, thus the brook flooded the nearby meadow. Consequently, another, straighter artificial channel was dug but before the end of the century the torrent cut its way through meadow (s). In the winter 1702/03 the brook flooded, damaged buildings, the deposition covered at least two meadows. Previous works in the stream bed influenced the distribution, per chance also the extent of damage. The study proves that in the observed time people were aware of the flood risk mitigating effect of cleaning the stream bed. Nonetheless, in this case it did not lead to frequent removal of

material deposited in the bed, but planned measures were oriented towards agrarian benefit and were too extensive to be ecologically sound (Zwitter 2017). From an interdisciplinary perspective, combining environmental and societal aspects, removal of gravel is only recommendable behind the barrages retaining huge amounts of deposits, and from gravel barriers (Stališče … 2014). One of the factors impeding stream bed cleaning activities was the lack of institutional support because involved people and plots of land belonged to various seigneuries (Zwitter 2017).

In some other cases seigneurial boundaries were successfully transgressed. Apart from agreements made by seigneuries themselves, a judicial procedure for which the office of the captain of the province (*Landeshauptmann*) was in charge, belonged to the means to reach this goal. The procedure from 1694, involving the office of the captain of Styria and referring to the flood hazard in the Lower Savinja Valley due to the Ložnica River and the Godomlja brook, offers a good example. The observed area is situated in a basin in the contact zone between pre-Alpine and sub-Pannonian regions (see Picture 1). Due to the fact that decisions were not desk-based but founded on field inspection, participants of which were also locals, traditional ecological knowledge influenced on the guidelines for the following works in stream beds and for stream bed management in the future. The risk reduction measures, envisaged by the court documentation, included also radical interventions — destruction of a masonry bridge to reduce the flood risk, and digging two channels to direct a section of a river and a section of a brook into them. Like in Jezersko, the beds of the Ložnica and the Godomlja had not been cleaned for a long time, but again, major interventions in the beds of streams were envisaged, including not only clearance of riparian vegetation, but also deepening the bed (Zwitter 2017).

2. EFFICIENCY OF PRESENTED INSTITUTIONAL SYSTEMS OF PROACTIVE COPING WITH NATURAL HAZARDS

On the one hand, institutional relief to a free peasant due to the disastrous mudflow in Lavanttal in 1660 was presented in this paper. On the other hand the same flood and the mudflow were major events; in the town of Wolfsberg (Picture 1, no 17), for instance a part of the hospital and a part of the town wall were eroded.[5] Among other damage, a water-powered hammer on Prössingbach or in its vicinity north of Wolfsberg was entirely eroded and its timber as well as charcoal and ore were washed away. It is clear that many plots of land in the Lavanttal were devastated too, including those, whose landlord was the bishopric of Bamberg (north of Nürnberg) (KLA 1662/63 a, Fresacher 1965 a). The latter was an important landlord in Carinthia, and there existed central administration for Carinthian

[5] It is important to note that in 1658 already, due to extremely wet weather, two burgher houses of the same town and a big part of the town wall collapsed to the Lavant River (KLA 1662/63 a). This evidently either did not stimulate the development of proactive coping strategies to prevent the damage in 1660 or it was impossible to stabilize the slope; the source in this case may describe complex landslides, not just simple consequences of lateral erosion.

possessions of this bishopric (Swatek 2005, Neumann 2007). Due to this disaster, Bamberg's Carinthian central administration asked the estates of the province for help. Among others, the application included 5 mudflow-stricken tenants of this bishopric in Obereberndorf, Gemmersdorf and Paierdorf (Picture 1, no 18); the disaster killed at least some family members and livestock, devastated agricultural land, also houses of at least some of these tenants were destroyed. Unlike in the case of the free peasant from Gemmersdorf, stricken by the same disaster, the estates of Carinthia rejected this application (KLA 1662/63 a-b). The fact that the process bringing the Habsburgs full sovereignty over Carinthian possessions of the bishopric of Bamberg was almost completed in 1535 but only concluded in 1674 (Neumann 2007), could have influenced this decision.

Numerous other examples prove that such legal issues were not the only problem making the presented systems of relief unreliable. On the one hand, other forms of help can be found in the sources, on the other hand lack of relief is proven by information on emigration in the time of successive harvest failures (Zwitter 2015 c) as well as on starvation (Blaznik 1970) and on inappropriate food substitutes, like bread from a mixture of tree bark and flax seeds after the very bad cereal and extremely bed wine harvest in Carniola in 1675 — a year of a very rainy summer and autumn (Zwitter 2014 a).

Other forms of help include alms for disaster affected people (e. g. neighbours, relatives, other people) or legal entities. Representatives of affected communities were at least in many cases themselves collecting the alms until 1760 s, when the respective institutional role of Church most probably rose (Zwitter 2017). According to data for mid 1720 s, Carinthian administration of the bishopric of Bamberg distributed alms to the poor in its centre — the Alpine town Wolfsberg (Picture 1, no 17) every week, despite the difficult economic situation of Bamberg in this province (Swatek 2005). In Škofja Loka, the town of the Bavarian bishopric of Freising (Picture 1, no 25), the monastery of Poor Clare Sisters received support from the Freising's seigneury of Škofja Loka after the river swept away the dam (or construction to stabilize the banks?) in 1612; to help this monastery, the mentioned seigneury provided 52 spruce, 60 beech and 60 oak trees from its forests (Blaznik 1973). In 1696, when the poor were suffering from food scarcity as a result of bad harvests and a fall in the value of money, alms were collected from house to house in Ljubljana — the capital of the province of Carniola (Picture 1, no 24); together with a contribution of the estates of the province these alms seem to have been invested into food, institutionally provided to several hundred poor people daily three months long (Valenčič 1977, Žmuc 2014, Zwitter 2017).

3. CULTURES OF RISK MANAGEMENT? PRESENCE AND ABSENCE OF RISK MANAGEMENT

The phrase "culture of risk management" (Rohr 2013, 135) "designates a bundle of well-rehearsed practices of risk minimization and ways of coping with extraordinary situations that people have integrated into their daily lives so as not to be taken by surprise" (Pfister 2011, pp. 4–5). Elements of a culture of risk management

are included in a report of crossing the Ljubelj/Loibl (Picture 1, no 11) in February 1631 by the Tyrolean prince archduke Leopold V. Before his journey, mortars were fired to trigger avalanches (cf. Tschaikner 2009). The main driving force for the development of strategies of coping with natural hazards in the early modern period was the memory of historical disaster experiences — usually the repeated ones (Pfister 2011), but also an example of memory of two single natural hazards, which, supported by a court ruling, stimulated adaptation without a recalled repetition will be given in this paper. On the limited space, selected case studies will lead us from high alpine pastures to agricultural land in the vicinity of permanent settlements, and, finally, to the beds of alpine streams.[6]

Grazing rules were in some cases resilient enough to include adaptations to climate change or at least to inter-annual fluctuations, e. g. to the summer cooling in the second half of the 16th century (for this trend in climate change see Dobrovolný *et al.* 2010, ZAMG: picture 1: changes in summer temperature in the Alps). In 1588, it was confirmed that the existing rule remained in power allowing the herdsmen grazing the animals on a part of the Dleskovec plateau above the isolated farm Planinšek (Picture 1, no 22), which is situated at the lower edge of this plateau, to drive the livestock to a lower shelter above the Planinšek farmstead in the case of adverse weather (Zwitter 2015 c). In some other cases, grazing rules were not so resilient, leading to a partial abandonment of some Alpine pastures due to the mentioned cooling. The source from 1579 proves it for the alp Belščica in the Karawanks, exceeding the altitude of 1900 meters (Picture 1, no 10), where horses and other livestock belonging to people from Vrba and Hraše (Picture 1, no 8) were allowed to be kept but due to the frequent snowing in summer time, only few animals were driven to that alp (Zwitter 2017).

The example of grazing rights of the villagers from Stein/Kamen, Seidendorf/Ždinja vas and Piskertschach/Piskrče (Picture 1, no 14) in Jauntal/Podjuna is particularly interesting. The crux of the dispute laid in the question if they all had the right to drive the livestock to the existing three commons or every village only had grazing rights on one of those commons. In 1615, the court ruling allowed livestock from all these villages access to all three commons, but every village had to keep or restore the good quality of pasture in one of these commons. The court took into account testimonies emphasizing the importance of observance of several decades old experience when extreme drought was followed by extreme flooding of the Drava River next year. In both cases, fodder on one of the mentioned three commons was destroyed. The second common was also threatened, but third one was situated higher — extremely important during floods — and springs were situated there, mitigating or eliminating the drought hazard. It was exactly the so important highest common, which was in 1615 to the highest degree overgrown by coniferous trees and thornbush. This proves that by having ordered the restoration of a high quality pasture there the court wanted to assure a larger extent of pastures than needed in normal years in order to strengthen the resilience of local animal

[6] For further examples see Zwitter 2015 a, c, 2017.

husbandry. The ruling also ordered to dig drainage ditches on a wet (marshy) part of that so important highest common (Zwitter 2014 b). It is important that in this case no repetition of the remembered types of natural hazards, but an institutional action was needed to pave the way leading towards a culture of risk management.

Drought hazard is in many places characteristic for inner-Alpine basins as a consequence of the combined impact of the rain shadow and the fact that these basins are filled with fluvial deposits, enabling a quick penetration of water from the surface to the groundwater. To mitigate this hazard, particularly problematic for grasslands, irrigation systems were used and maintained in the observed time, enabling not only higher, more stable yields, but also better quality of hay. An investigation of the history of irrigation in Jauntal/Podjuna based on sources of one seigneury from the first two decades of the 17th century proved irrigation in the southern, western, northern and eastern part of the drought prone flatland; a source from 1654 mentioned also an adaptation of an irrigation system to dynamic environmental conditions after the brook changed its bed during a flood event. Most probably at least some of these irrigation systems could also be used for flood risk mitigation; an interviewee from Traundorf/Strpna vas (Picture 1, no 16) recalled that water was directed to the meadows also to limit the amount of water reaching the village. The examples of these traditional irrigation systems at Traundorf/Strpna vas and Gösselsdorf/Goselna vas (Picture 1, no 15) make clear that their reestablishment would not be possible due to the profound man made changes in watercourses but these 20th century measures importantly decreased the flood hazard to the villages (Zwitter 2014 b, 2017). The historical situation in another sub-Alpine flatland — the Dežela in the Ljubljana basin — was different. According to a source from 1579 people and seigneuries with land situated to the right of the Blatnica brook, where drought represented an important hazard, were not allowed to irrigate the meadows, because all the water had to reach the demesne meadow of the seigneury of Radovljica below the village Hlebce (Picture 1, no 9; historical data: Zwitter 2016; general hydrological conditions: Melik 1959).

The number of houses devastated by the major flood in Val Canale in the second half of July 1619 was low — two in Pontebba (Picture 1, no 1) and one in S. Leopoldo (Picture 1, no 2) which implicitly demonstrates that settlement places in the valley were to a high degree adapted to flood hazard. It is interesting that wood for iron processing in Malborghetto (Picture 1, no 4), e. g. for charcoal, was washed away, thus it was not kept at a flood-safe place, but one has to bear in mind that it was not a regular flood as clearly demonstrated by the severe damage in the river bed and banks. Allegedly, all water powered mills on the bottom of the valley from Pontebba to Tarvisio (Picture 1, no 6) were damaged. Not only older bridges but also a new stone bridge at S. Leopoldo was partly destroyed. The damage, caused to the bridge in S. Caterina (Picture 1, no 3) included wooden frameworks, probably filled with stones, on which the construction of the bridge rested. In Tarvisio, some dams or constructions on the banks and millraces were eroded, the same happened in Malborghetto with all dams or constructions on banks, all millraces, together with wooden frameworks, probably filled with stones, and protective

constructions[7] at water-powered machinery. Even a recently (1618) erected several tens of strides long protective construction to safeguard the road at Ugovizza (Picture 1, no 5) was eroded (KLA 1619 a).

Similarly, on 16 and 17 September, two months after the major flood, the alpine brook Pontebbana flooded and the reaction of officials in Pontebba (Picture 1, no 1) represents a simple example of traditional ecological knowledge: when the water reached the vicinity of the administrative buildings, they retreated to a safe location. However, the provisional restoration of the bridge in Pontebba after the July flood did not take into account the flood hazard — the bridge again did not withstand the flood of the brook Pontebbana. On that occasion, the discharge of the brook must have been very high, as it destroyed also a big building for iron processing, situated near this bridge (KLA 1619 b).

The sources of the already mentioned court procedure in Styria from 1694 in the Lower Savinja Valley are instructive because this study demonstrates, how a natural hazard adapted "traditional" landscape, economy and society are in many cases results of a gradual evolution, whose historical development most probably included positive and negative trends, at least if we are dealing with an area where high-magnitude events were not frequent (cf. Raška and Brázdil 2015). These sources prove many imprudent or one-sided interventions, raising the flood risk in the Lower Savinja valley (see Picture 1) before the field inspection. The facts that flood hazard threatened fields and a road, thus important pillars of local economy, together with the fact that vegetation blocking the flow of the swollen streams was not cleared, prove that in this area, the life was, generally speaking, only to a very limited degree adapted to flooding. An unsuitable bridge was built, which too much blocked the flow of the swollen stream, a wooden barrier crossed the brook to prevent livestock from entering the cultivated land but, again, in case of a high discharge, it decelerated the flow too much. The dyke built along the brook above the bridge to prevent flood events was situated too close to the stream, so that the swollen stream flooded. Mill dams were raised in the flatland and an unsuitable ditch was dug. Also track erosion on a cart track crossing the river raised flood risk to agricultural land. On the other hand, a successful historical construction preventing flooding at that part of the river is documented as well (Zwitter 2017). Another example of a gradual evolution towards the natural hazard adapted cultural landscape is building of a new grain mill in the common of the market town (Eisen)Kappel/(Železna) Kapla (Picture 1, no 13) in 1697 to be used by two nearby isolated farms instead of the one on a more flood prone plot (Zwitter 2016, 2017).

4. LESSONS FOR THE FUTURE

Environment has been changing and will continue to vary due to natural and human causes. Firstly, this calls for a long-term approach enabling learning from history, which in the context of natural hazards calls for taking into account not

[7] Deutsches Wörterbuch von Jakob Grimm und Wilhelm Grimm: Fürschlag.

only data from recent centuries as industrial period and era of instrumental measurements, but also pieces of information from distant past, e. g. the 16th and 17th centuries, to be better prepared for present-day and future. Secondly, one has to think, whether the interacting environmental and societal conditions in question either are similar enough to the ones at a certain moment in the past or it is likely that they will in the future resemble the former ones to such a degree that learning from the early modern history can improve the strategies of coping with natural hazards in the 21st century. Thirdly, legacies of historical interactions between people and environment influence the risks posed by some natural hazards today (cf. Winiwarter *et al.* 2013, cf. Schmid 2016, cf. Winiwarter *et al.* 2016). The chapter is divided in three main types of lessons we can learn from early modern natural hazards.

4. 1. Which areas are threatened by natural hazards?

Two of the types of natural hazards in the Alps, for which historical knowledge is highly relevant, are avalanches and landslides, thus the chapter will give these examples.

According to existing data for the period 1843–1998, one third of all casualties of natural hazards on the territory of present day Slovenia died of avalanches. Furthermore, a long-term perspective reveals that some places are actually threatened by avalanches, although these localities are considered safe because a long absence of suitable conditions interrupted the knowledge transfer between generations. Even if a former sloping surface has in the meantime been overgrown by such type of a forest, which does not allow formation of an avalanche at present, historical data can be used preventively because the avalanche hazard can appear there again if the forest is cut or destroyed (Pavšek 2000, 2002) — e. g. by fire, windfall, European spruce bark beetle or glaze. An example of a location where historical experience of an avalanche hazard has not been registered yet in the existing evidence of historical avalanches, which is far from being complete (see map in Pavšek 2002, p. 30), is the location of the church of St. Leonard (929 m a. s. l.; see Picture 1, no 23) on the slope to the east of Lepenatka mountain. Before 1426 a church was built there or in the vicinity and in 1880 s the year 1529 was read on the church floor (Janisch 1885). In the winter 1894/95, characterized by unusually high number of avalanches in the populated parts of the mountains in its surroundings (Zwitter 2015 b), an avalanche severely damaged this church and filled the ruins with snow, rocks and wood. Furthermore, the avalanche continued its way and carried away also the mill below the church (Stegenšek 1905). The situation of the brook, which must have driven the mill, reveals that the avalanche hit the church from S or SW and was either triggered in a sparse forest/pasture with trees or at least crossed it, because the avalanche carried wood to the church. In the same year the church was rebuilt on the same location where it still stands (Zwitter 2017). It is an example of a building on a location prone to avalanches, but, as frequently the case with "traditional" buildings, "out of the usual path of destruction" (Pfister 2011, p. 5). Erosion of traditional ecological knowledge and

non-observance of historical avalanche experience has in the Alps led also to erection of buildings in much more avalanche prone areas, which in some cases like in Galtür (Northern Tyrol) already resulted in numerous casualties, many injured people and huge material damage (Rohr 2009). Historical data can also help upgrade models of avalanche hazard, if only locations of avalanches in the past are reported with adequate precision (Pavšek 2000, 2002).

Examples of historical landslides are relevant, because a landslide is often followed by further landslides above or below on the slope; destabilization of the slope by the previous landslide plays an important role (Zorn and Komac 2008). A source from 1570 documents, that a mass movement[8] devastated the forest in possession of the isolated farm Pečnik in Kot pri Prevaljah (Picture 1, no 20; see Picture 2), plot boundaries reveal that it evidently took place on the slope to the SW of the farmstead (ARS 1827, ARS 1828, ARS ca. 1830, Environmental Atlas …, Zwitter 2016). A mass movement is not documented there in the existing database, which includes more than 3.250 locations of slope mass movements in Slovenia but is still far from being complete (Komac *et al.* 2007, Zorn and Komac 2008). The same applies for another as yet unknown quite big historical landslide — on the eastern slope of the Logarska valley in March 1934. Experts of the time estimated that it affected about 8.5 ha. It started on the territory belonging to the Klemenšek farm, destroyed also larch trees which were several hundreds of years old and was heading towards the Plesnik farmstead at the bottom of the valley (Picture 1, no 21), but, fortunately, changed its direction (ŽU Nova Štifta 1934).[9] If a further study proves that these areas of historical landslides can become active again, awareness of their existence as result of archival sources analysis can stimulate a higher resilience to these hazards in the future. As explained by Zorn and Komac (2008), such historical data would — if they were more numerous — have a potential not only to contribute to locally raised resilience but also to improve existing models of landslide hazard based on analysis of spatial distribution of factors leading to landslides in combination with the database of known landslides. Likelihood for another landslide in the same location can raise with chronological distance from the previous one.

[8] The expression "preg län" (NŠAL, KAL 1570, fol. 174 v), used in this source to characterize the process which is reported to have caused extensive damage by having covered the forest, evidently refers to a landslide; "län" could also be an avalanche, but "perg", i. e. "Berg", hill/mountain, makes clear what was mentioned; in the case of an avalanche, not material which had previously formed a part of the hill, but the snow would have represented the majority of the deposition.

[9] Snow melt and heavy precipitation events belong to triggers of landslides (Zorn and Komac 2008) and at that time a deep snow blanket was melting (ŽU Nova Štifta 1934). According to the measurements from immediate vicinity, the amount of precipitation of that March (299 mm) was 2.5 the average of the period 1925–1940, the daily amount of precipitation on 13 March (108 mm) represents the maximal daily March precipitation in the period 1925–1940 (Prilozi … 1957).

Picture 2: One of locations of extensive, most probably repeated depositions of mass movements in Pečnik's forest in geological history is the concave gentle slope W of the Ravnjak farmstead. Photo represents the partial cross-section of the southern edge of these deposits; note the convex landform of the deposited material. The latter includes various fractions, e. g. sand, gravel, rocks of various dimensions. If the mass movement in the 16th century affected this gentle slope, it not only destroyed that part of the forest, but it also rendered the access to a major part of Pečnik's forest difficult. Locals remember landslides in the vicinity of the Pečnik farmstead about 40 years ago and observe geomorphological changes in their cultivated land due to mass movements, but do not remember mass movements higher — in the forest. Nonetheless, they recall a natural desiccation of a lake in a little depression of the same slope, at about 850 m a. s. l. (Locals with a personal experience of playing with a little raft in the lake, when they were kids, are still alive. About 30 years ago, the lake was still there, the depression was dry only during drought events. The desiccation took place much earlier than the forest road was built in the vicinity, so this change in hydrological conditions is not a result of the road construction (Mr. Štajner, pers. comm. 2016)). — Another proof of slope dynamics (Mr. Štajner, pers. comm. 2016). The mentioned forest on gentle slope is situated above the farm Ravnjak and a weekend cottage. A future study of mass movements in that forest inspired by information from 1570 can prove, whether agricultural land, buildings and road are seriously threatened. The lidar map strongly suggests it for the Ravnjak farmstead (Environmental atlas …).

4. 2. A possible contribution of history to estimation of severity of hazards with long return periods

The topic will be presented on the example of floods. Estimation of severity of floods with long return periods (e. g. 100 years and more), which is crucial for adequate flood risk coping strategies, is usually based on statistical extrapolation of

much shorter series of known data on flood frequency and severity. In order to increase the reliability of results, two kinds of methods have been used, enabling the extension back e. g. to the 16th century: (1) modelling and (2) use of historical and palaeoflood results. Not only data for the catchment in question but also those for comparable catchments can be useful. When applying historical — documentary evidence, which is the topic of my paper, to research in flood hydrology, important for the present day and future, (1) included data have to be obtained by historical-critical research, (2) one has to know, (a) if data for all years of considerable floods are represented in archival records or on high water marks, or (b) only some extreme events were found in the archives or are marked as water level markers, or (c) the number of years and/or minimal severity of floods, for which data is available in the analysed series, changes over time. (3) Climate change, natural and anthropogenic changes in river bed, and land-use change have to be addressed as well. Historical data e. g. enabled to find out that the estimation of the discharge of the flood with a 500-year return period of the Ebro River in Spain at Tortosa below the mountains based only on instrumental measurements was less than ⅔ of the same estimation including also historical data and the estimation of the discharge of the flood with a 100-year return period in the first case was about ¾ of the same estimation including also historical data. Documentary data can help also understand long-term variations in seasons of flood events. Moreover, historical data can illustratively present flood hazard also to non-experts. In Slovenia, the importance of use of historical data for flood frequency estimation has not been recognized yet, whereas in its Alpine neighbour state Austria historical data have been routinely used for this purpose (Kjeldsen *et al.* 2014).

4. 3. Learning from (un)successful historical practices of coping with natural hazards

Environmental history teaches that people have not entirely understood complex ecosystems in which they intervene, which still holds true for present-day experts (Schmid 2016). It is thus inappropriate that in some countries current coping with natural hazards includes commissions "established by political representatives and by members of the rescue services according to specific legislative norms, i. e. without any systematic participation of the public" (Raška and Brázdil 2015, esp. p. 176). The determination of coping strategies in the presented 17th century examples from the Lower Savinja valley (1694) and Jauntal (1615) took into account local traditional ecological knowledge. In the 16th and 17th centuries its role was bigger than today because the knowledge of experts was more limited. However, it is still important to take into account also local knowledge, evaluate it scientifically and combine the scientific background with the valuable traditional knowledge to develop more efficient coping strategies (cf. Hernández-Morcillo *et al.* 2014).

In some cases, inscriptions in situ documented historically experienced natural hazards and were a memento for future generations (Rohr 2009). In the late 17th century, it was documented that ossuaries at two Alpine churches on each side of the important pass Ljubelj/Loibl in the Karawanks (Picture 1, no 11) were

preserving bones of casualties of avalanches (Panjek 2005) — they were an example of such a memento for those travellers who noted their role. Another example have been high water marks, which not only have kept remembering people that an area has been flood prone, but have also made clear, how often a flood of a certain magnitude appeared since the high water mark had been in use (Pfister 2011); however, some high water marks were erected only much after the flood, thus were less reliable, or were even displaced, which could entirely alter their message (Rohr 2012). Keeping and updating such monuments with a memento function is not ubiquitous. Cases of disappearance of such historical inscriptions during the 20th century mark the vanishing of awareness of natural hazard threat (Rohr 2009). On the other hand, actions have recently been carried out to (re)introduce this plain but successful historical way of informing people about flood hazards, e. g. in some Alpine parts of Slovenia (like the high water mark on the bridge crossing the Ribnica River at Stara Fužina (Picture 1, no 7).

CONCLUSIONS

A long-term existence of both, institutional and non-institutional systems of coping with natural hazards is characteristic for Slovene Alps and their surroundings. People whose buildings or land were threatened by natural hazards have in many cases gradually adapted to them, so that extensive damage was caused mainly by unusually extensive events. The rate of traditional adaptation varied, the process of adaptation was influenced not only by the frequency and severity of disaster experience, but also by institutional actions — these included not only challenges, e. g. territorial dispersal of seigneuries and the question, how well the neighbouring seigneuries cooperated, but also institutional incentives, like the court ruling paving the path leading towards a culture of risk management based on memory of two single, not repeated hazard experiences.

Despite this long-term history, people in the late 20th and early 21st century in cases of natural disasters again and again face issues of insufficient adaptation to natural hazards — among them also those, which were already clearly recognized as problematic in the 16th and 17th centuries, like too narrow and too low bridges. There are three main reasons for this insufficient state of learning from history, which will have to be improved in the future. Firstly, traditional ecological knowledge has been disappearing and has not been adequately taken into consideration. Secondly, historical records have only partially been studied, meaning that important long-term data on natural hazards are still hidden in the archives, waiting to be interpreted using historical-critical method. Thirdly, in many cases the relevance of historical data is not evident due to later natural and man-made environmental changes; thus there is a need for a stronger cooperation between environmental historians, local inhabitants and experts involved in coping with natural hazards at present.

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Žiga ZWITTER

PROAKTIVNI ODNOS OD 16. DO RANOG 18. VIJEKA PREMA PRIRODNIM OPASNOSTIMA U SLOVENAČKIM ALPIMA I NJIHOVOM OKRUŽENJU, SA NAUČENIM LEKCIJAMA ZA BUDUĆNOST

Rezime

U radu su predstavljene strategije prevladavanja prirodnih opasnosti u slovenskim Alpima i okolini od 16. do početka 18. vijeka. Također se razmatra efikasnost primijenjenih institucionalnih strategija. Rezultati jasno pokazuju da je proces adaptacije na razmatrane opasnosti postepen. Identifikovani su sljedeći mogući doprinosi životnoj sredini u suočavanju sa ranijim modernim opasnostima kako bi se bolje pripremila i prilagodila u budućnosti: (1) identifikacija područja podložnih opasnostima, (2) bolja procjena opsega opasnosti sa dugim povratnim periodima, i (3) (ne)uspješne istorijske prakse u rješavanju prirodnih opasnosti.

Ključne riječi: *ekološka istorija, rani moderni period, planine, poplave, klizišta, lavine*