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The impact of demographic developments on flood risk management systems in rural regions in the Alpine Arc

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ABSTRACT

Demographic trends across Europe indicate that many regions face sustained population decline due to aging and out-migration. Rural regions are often prone to flood hazards and have repeatedly been affected by damaging events in the past. However, we lack in-depth knowledge about how demographic trends challenge their capacities, abilities, and plans to manage flood risks. In this paper, we aim to close this gap. We employed a mixed-methods approach in the Gailtal-region in Carinthia (Austria), which combines the assessment of exposure to flood risk, social vulnerability, coping ability and adaptation capacity, as well as a discourse analysis. This comprehensive approach was designed to assess how demographic change impacts flood risk management. The findings do not support the hypothesis that population decline increases communities' social vulnerability and reduces their coping ability and adaptation capacity. Additionally, the selected municipalities showed a strong increase in exposure. This is an example of the exposure paradox, which describes the phenomenon that settlement and population dynamics are not interconnected at all, especially in regions with a limited share of suitable land. Finally, our results show that current flood risk management and the corresponding social and political discourse mainly neglect the challenge of population decline. Overall, this study indicates that public administrations need to address the challenges of weak communities in flood risk management and consider how they might empower local authorities and citizens to adapt to future events – in full consideration of the demographic trends they have to expect.

1. Introduction

Many rural regions in Europe, which are located far away from urban centers, face persistent sociodemographic changes, especially population decline due to aging and out-migration [1]. Various studies expect that local municipalities in particular mountain regions, such as in the Alps, will face enormous sociodemographic changes within the next decades [2,3]. In Austria, for example, over the past decades approximately one-third of rural areas have experienced such developments [4]. These developments heavily influence those areas' economic capacities and exacerbate the negative impact on job opportunities, access to public services or trans-

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port services, health coverage or cultural activities. Consequently, rural communities "may enter into a 'vicious circle of decline'" [1]; p. 5). In addition, many of these communities are prone to flood hazards, which typically are intensive to manage in terms of financial and personnel resources [5]. Based on preceding studies [5–9]; , sociodemographic changes appear to be a highly relevant factor in flood risk management. They can affect the level of risk (above all the factors vulnerability and exposure), which confronts risk management with new challenges in terms of selecting and implementing risk reduction measures.

This brings us to a scenario that is often portrayed as prototypical in the literature: A region with a declining number of inhabitants is confronted with a lack of financial resources to provide flood protection schemes, might have less exposed buildings in the near future, and might face challenges in terms of special needs during an event and the following recovery. Accordingly, existing studies predominantly focus on the characteristics of increasing vulnerability, a low degree of preparedness and a lack of risk management strategies due to population decline and aging. However, many of these studies focus on disadvantaged communities in the United States or local communities in developing countries, but seldom on rural communities in Central Europe. While rural municipalities in the alpine area are indeed facing sociodemographic challenges, such as population decline and aging, they are not necessarily poor or disadvantaged. This raises the fundamental question of whether the "vicious cycle" thesis applies equally to these European communities. This lack of insight makes it particularly hard to understand how factors that are of major relevance to flood risk management (vulnerability, coping ability, adaptation capacities and exposure) interrelate with sociodemographic changes (such as aging and outmigration). Generally, aging communities and individuals are seen as more socially vulnerable and having a lower coping ability and adaptation capacities toward flood events as they are less mobile, more physically frail, and depend more heavily on external support. In addition, it is assumed that communities that are facing a declining population usually suffer from less political and socioeconomic support by regional and national authorities. Usually, aging communities suffer from lower tax revenues or show a lower cost-benefit ratio as fewer people are living there, which also results in a lack of financial support for technical mitigation measures. However, population decline also means no increase in exposed residential and nonresidential buildings in floodplains. As an attempt to bring some light into multifaceted constellations such as this, this study provides a case study of a typical rural district in the Austrian Alps. Our focus on one case study allowed us to paint a comprehensive picture of the current situation, expected developments, and plans to deal with them. This promises insights from which both researchers and practitioners in the area of flood risk management could learn. For our in-depth study we selected a part of the Gailtal, a valley around the river Gail in the Austrian province of Carinthia. Gailtal is a remote rural area (the next larger city with more than 100,000 inhabitants is an hour drive away) that experiences persistent population decline, and is often struck by floods. Our examination allowed us to answer the following research questions.

- How are demographic developments interlinked with vulnerability, coping ability and adaptation capacities?
- Are demographic changes affecting land use planning decisions?
- Are politically responsible actors aware of demographic developments challenging flood risk management, and how do they react?

We decided to apply a mixed-methods approach, which combines a broad variety of sources, first, "to consider multiple viewpoints, perspectives, and standpoints" [10], and, second, to accommodate the variety of interlinkages between the different topics and to reach a better understanding of the very complex phenomenon of the impact of demographic change on flood risk management [11]. To address this challenge, our study assesses, first, the development of flood risk in the case study region, as well as, second, respective changes for the management of flood risk – both with a special focus on the impacts of demographic developments. Finally, we aimed to examine relations between those changes and the problem awareness as well as policy responses of responsible political actors.

2. Influence of demographic change on flood risk management

The current research on natural hazard risk management shows strong linkages between sociodemographic changes and individual as well as collective risk management [12]. However, most studies focus on urban areas discussing settlement growth and hazard exposure. Only a few studies pay attention to areas facing population decline despite the obvious differences in vulnerability of urban and rural areas. The prevailing opinion in the literature is that small rural communities are particularly vulnerable to far fewer and steadily declining resources [13], but the literature is often less clear and more ambiguous than one would expect. In the following we will outline the potential impacts of demographic change on flood risk management in terms of vulnerability, exposure and risk management strategies. Vulnerability is based on the assessment of the social and physical damages caused by an event [14]. The imperative of vulnerability and sociodemographic change is usually understood as aging and out-migration increasing the individual and local social vulnerability to flood hazards [6]. Key factors are older people being less mobile, more fragile, in demand of further assistance during an event (as well as for recovery), more often request special medical equipment or are often financially weak [15]; [14,16,17]. However, the life experiences of older people might help to organize and quickly overcome current flood events [14,18–20]. In addition [7], report that older people are more likely to hold insurance. A similar argument is observed in the current debate on individual preparedness, which is often defined as the individual coping ability and adaptive capacity. Using the [21] definitions, coping ability is the current degree of how well a household or business can absorb and recover from an event, while adaptive capacity refers to the ability of a household or business to undertake private preparedness actions now to reduce its future vulnerability or to improve its future coping ability. In terms of sociodemographic change, older householders are usually seen as less able to cope with and less willing to adapt to natural hazards [12]. A key factor is risk perception which influences individual coping ability and adaptive capacity [22,23]. However, researchers dealing with age group-specific risk perception come to diverging conclusions. Some authors argue that older people usually have a higher risk perception and awareness (e.g. Ref. [24], while others doubt that age is a significant determinant of natural hazard risk perception [23,25]. In terms of precautionary measures, the respective findings are also ambivalent. Some authors claim that older people are more likely to take them [26], whereas others argue that older people tend to object to adaptive measures [27]. However, again there are several researchers who question the relevance of age in this regard. They conclude that there is no major correlation between age and being willing to adapt or between age and being cautious (e.g. [28]).

Additionally, concerning the spatiotemporal dynamics of exposure, we observed a similar argument. There is a general understanding that population growth increases the number of buildings being exposed to flooding, especially when there is only limited suitable and accessible space outside of flood prone areas [29]. Upon reversion, population decline would encourage a reduction in exposed residential and nonresidential buildings in the region.

Finally, sociodemographic changes may also influence risk management strategies or at least the requirements actors (should) refer to Ref. [5]. However, recent findings imply that even when the risk management community in a particular region is well aware of challenges resulting from demographic changes, there might be a gap: While outmigration and aging in rural areas, as well as changes in household structures and composition, might affect the question of which measures should or can be implemented to reduce future risk, those who are in charge of developing answers to this question do not necessarily adapt to these developments [5,12].

3. Methodology

To integrate all of these (potential) interrelations, we developed a mixed-methods approach that combines spatiotemporal assessment, semistructured interviews, a household survey, and discourse analysis. It was designed to collect and analyze qualitative and quantitative data, which allows us to capture the problem of sociodemographic change and its impact on flood risk management from a broad perspective. Although each methodological step follows its own analytical focus, all of them were designed along our overarching research interest. We are convinced that the complexity of the issue, including the lack of studies establishing the link between demographic developments and flood risk management, requires an integrative approach that combines various analytical inputs. Fig. 1 provides an overview of, first, the analytical steps that were conducted (= orange circles) and, second, the overarching analytical categories (= blue boxes), which structure our research findings and following conclusions. Those categories were jointly fed by different analytical steps. The description of demographic developments is based on historical and current statistical data. Based on that preceding step, as Fig. 1 shows, the assessment of the flood risk and its development is based on an exposure analysis, while the assessment of the impact of demographic developments on flood risk management is based on a survey that allows us to analyze vulnerability and coping capacities in the case study region. The results from the same survey also inform our assessment of the local and regional problem awareness and according policy response – in combination with a discourse analysis and semistructured expert interviews. In combination, these steps constitute our assessment of the impacts of sociodemographic change on the case study region's FRM and respective political developments (see Fig. 2).

3.1. *Survey*

From August 2019 to February 2020, we conducted our survey, which was added to a newspaper in each of the four selected municipalities, with a response rate of 7.8%. The respondents were fairly distributed across the four local authorities in the Gailtal. The sample shows a stronger population segments of males, who had previous flood experiences, high age, high rate of ownership and where family members (or they themselves) were volunteers in blue light organizations, like emergency management or fire brigades, who were overrepresented to some degree (Appendix 1), but in the line with previous surveys conducted in Austria. Therefore, the results on social vulnerability, individual coping ability and adaptive capacities need to be assessed with some caution, because of the potential self-selection bias by interviewees.

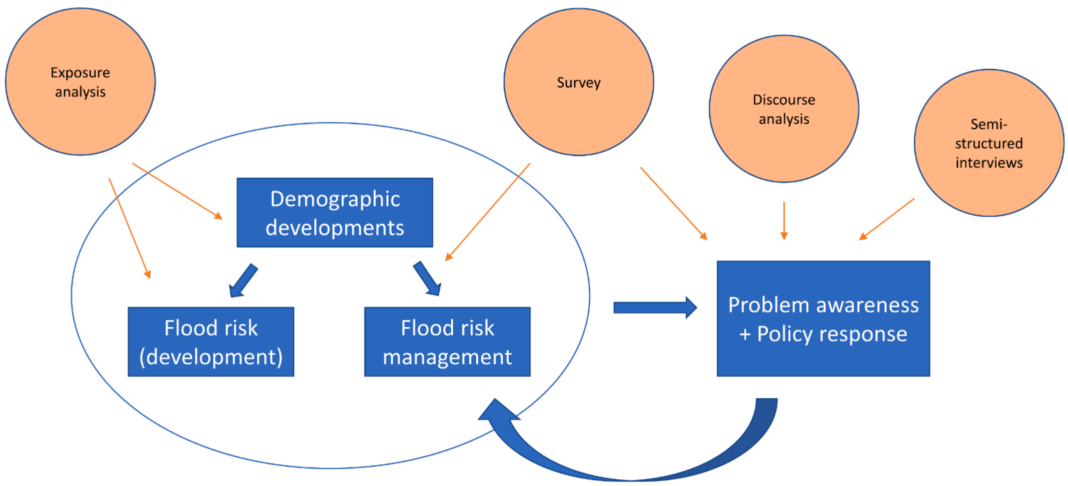

Fig. 1. Methodological approach.

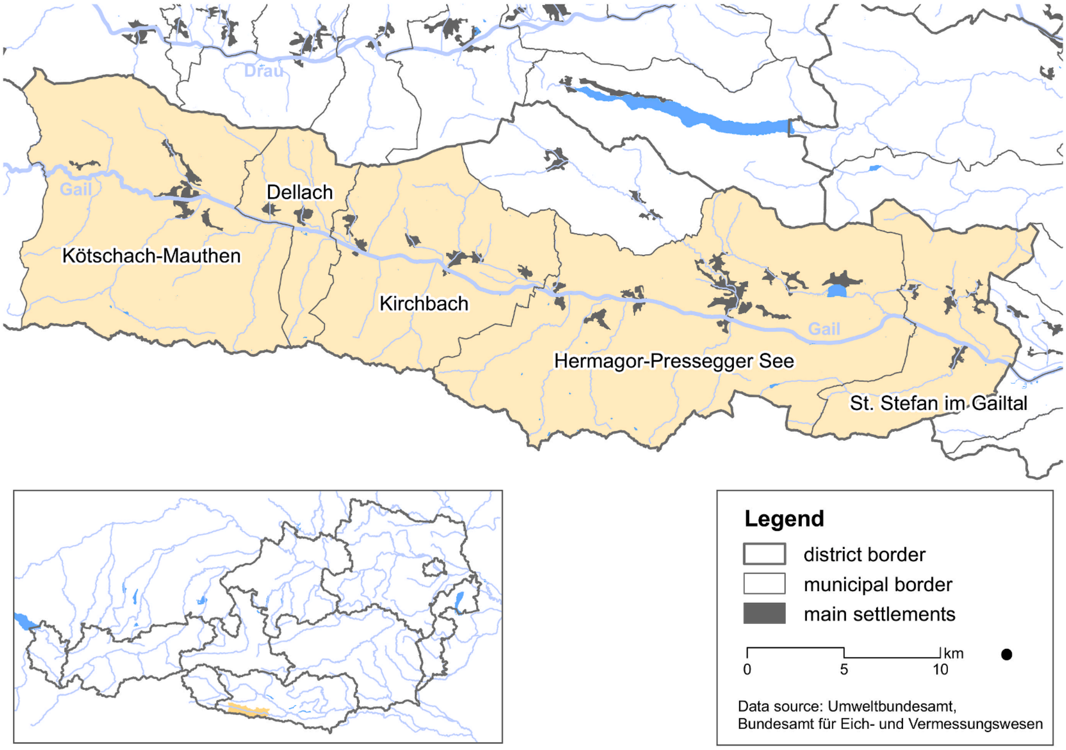

Fig. 2. Study site – Gailtal.

The survey was distinguished by four core thematic themes: (1) assessment of the current social network and capital, (2) individual risk perception, (3) preparedness before and after the 2018 event, and (4) sociodemographic characteristics. The aim of the survey was to analyze the individual social vulnerability, coping ability and adaptive capacities in communities with high sociodemographic changes in recent years. Social capital and networks were measured within the survey by three main indicators: (1) mutual trust, reciprocity, and engagement within the municipality in terms of taking part in events, organizing events, members in various local organizations (5 items; [30,31], (2) reliance on social support, and help from neighborhoods during the past event (3 items [32]; and (3) members of blue light organizations (1 item; [33]. Risk perception was measured by three indicators: (1) experiences of past events (2 items based on [34] and [35], (2) evacuation (1 item based on [7] and (3) perceived likelihood of municipal and individual damage (1 item, [7]. The assessment of preparedness included individual preparedness (3 items based on [34,36], risk awareness (2 items based on [7], reliance on public flood risk management (1 item based on [37]) and collective efficiency (1 item based on [38]. Sociodemographic characteristics included information on household composition, including the number of household members with special needs, such as disabilities or children. Additionally, sociodemographic characteristics included gender, income, education, ownership and use of residents (principal or second residence) [6]. The analysis was conducted on Pearson correlation coefficients, the chi-squared test, and multivariate analysis of variance (MANOVA) in SPSS.

3.2. Exposure analysis

The exposure analysis was generated in ArcGIS and is a microscale assessment of settlements affected by flooding. The analysis examined two different periods of time, one in retrospective (1998–2019), the other is a future estimation (potential development with no timeline). To assess the newly exposed buildings, we used the current building stock according to the digital cadastre map (BEV 2019) and overlapped and matched it with an aerial photo from 1998 [39]. The flooding zones were based on the areas of a 1:100 and 1:300 flood-zone defined by the Federal Water Engineering Administration [40,41] and the torrent catchment area of the hazard zone plan by the Forest Technical Service for Torrent and Avalanche Control [42]; Appendix 2). For the future estimation the Municipal Development Plans and Land Use Plans [43] were used to select all building plots, defined as areas for residential use. These plots were separated into properties with buildings (current situation) and properties without buildings (potential future development) according to the digital cadastral map and the latest aerial photo. They were then intersected with the areas subjected to flooding using the same data as before.

3.3. Semistructured interviews

Between March 2019 and January 2020, we conducted 15 expert interviews with administration officials, mayors, planners, and rescue organizations at the federal, state, and local level. The interviews provide insights into the impact of demographic change on vulnerability, coping ability and adaptive capacities in general and within the selected study region in particular. For the interviews we used structured open-ended questions related to various analytical categories, inter alia (i) the regulatory framework, (ii) awareness of demographic change and its potential impact, (iii) information and communication with groups that have special needs, (iv) challenges in the case of events, and (v) cooperation between administrations and organizations. They lasted between 30 and 60 min and were transcribed and analyzed using the qualitative software programme MAXQDA [44,45].

3.4. Discourse analysis

The science of socioecological issues is particularly complex. Therefore, experts also make use of narratives to transmit meaning(s) [46]. A critical analysis of discourses helps to understand these narratives. Our concept of discourse and the corresponding analysis is based on [46,47]; who understands discourse as "an ensemble of ideas, concepts, and categories, through which meaning is given to social and physical phenomena, and which is produced and reproduced through an identifiable set of practices" [47]; p. 67). To understand if and how the existing knowledge and awareness affect the framework of policy-making, we analyzed the representation of connections between demographic change and flood risk management in public and political discourses, if discursive practices were adapting accordingly, and what the discourses and discursive practices tell us about the reactions of political actors. The ADA allows us to understand how the (potential) impacts of demographic change on flood risk management are connected to its historically specific social, economic, political, and institutional context, how discourse, relevant knowledge, strategic actions and institutional patterns are related to each other, and how/if political change is happening accordingly [46]. The final interpretation of this information aimed to find a discursive order that governs the domain we were examining between 2016 and 2019 (for details on the sources see Appendix 3).

4. Case study description

The study area is located in the district of Hermagor in Gailtal, a valley that is part of the province of Carinthia in southern Austria. The site was selected for an in-depth case study due to its location in the alpine area, the high flood risk it is exposed to, and serious demographic change. Hermagor is facing population decline, from 20,245 inhabitants in 1991 to 18,224 in 2019 [48]. Taking a look at the age-related change, the region has experienced a decline of inhabitants under the age of 60, while the Group 60+ was increasing between 2013 and 2019 by 10% [48]. In 2013 29% of the population was over the age of 59, while in 2019 the percentage further increased to 33% [48]. Comparing the number of births and the number of deaths demonstrates a natural population decline of 482, which results in a general decrease of 555 inhabitants between 2013 and 2019 [49]. The prognosis predicts further population decline of 13% until 2040 in the district of Hermagor [50].

In addition to the challenges of demographic change, flood hazards have always been present in the Gailtal region. In Carinthia, flood events have been recorded since 1195 [51]. Some of the major floods took place in 1965 and 1966, which claimed lives, villages had to be evacuated, many houses were under water, bridges were destroyed and roads were blocked [51].

The most recent events in 2018 and 2019 confronted regional and local flood risk management with major challenges. On October 27th, 2018, public authorities and emergency personnel were alerted due to continuous rain. Experts expected a 1:30 to 1:100 flood, and the regional authorities assessed the flood measures to be sufficient. During the night from October 29th to 30th a dam broke in the village of Rattendorf (municipality of Hermagor-Pressegger See). The water flooded 39 houses, washed away roads, damaged and, in two cases, tore away bridges. In terms of fatalities the event caused no injured or dead people. Before, during and after the flood, 5300 fire fighters were in action, supported by the Austrian armed forces. According to a newspaper report from September 2019 the flood caused damages of EUR 233 million (Kleine Zeitung, 9/17/2019). In mid-November 2019 another major flood event was expected due to heavy rain and a rise in the snowfall line. It hit several regions all over the state of Carinthia. Houses had to be secured with sandbags and roads were flooded. For the Gailtal, this event was less serious than the one in 2018. The damages in the whole state of Carinthia were expected to be "hundreds of millions" (Kleine Zeitung, 11/27/2019), approximately EUR 100 million in the private sector.

5. Results

5.1. Social vulnerability characteristics

The management of flood risk increasingly builds on the notion that vulnerability has to be understood as a dynamic process [12]. It is therefore crucial to acknowledge the main demographic characteristics of the case study population. In our case, the majority of the respondents (81.8%) owns their own property (in most cases detached houses; 73.3%). Other sociodemographic information, such as level of education, income, employment, etc., are in line with the census data. The majority of the respondents had no higher education degrees. More than 34.6% have completed an apprenticeship, and 19.5% have completed vocational middle school training. The average household income is below EUR 3000 (net), and approximately 47% of the respondents have a full-time job. The social capital within the communities can be described as quite strong. First, many of the respondents are members of blue light organizations, such as voluntary fire brigades and/or the Red Cross. In addition, more than 45% of the respondents are active members in local associations, such as choirs, music or theatre groups. In addition, almost every respondent (96.5%) lives in the case study area (many of them were born and raised there) and does not use the property as a second home. This also reflects the question about social identity and support, where the mean value is 3.6474 (min = 1 and max = 5) with a SD of 0.977 (see Table 1). Analyzing social vulnerability, the number of householders who need special care is approximately 10.7%.

Table 1
Risk awareness and preparedness.

Items	No. Valid	No. Missing	Mean	FD	Minimum	Maximum
Social cohesion	312	6	3.65	0.98	1	5
Risk to community	295	23	2.67	1.14	1	5
Risk to private property	290	28	2.18	1.16	1	5
Risk to individual life	276	42	1.59	0.94	1	5
Expectations to future flood events	306	12	0.55	0.53	0	2
Individual preparedness to 2018 flood event	306	12	2.45	1.29	1	5
Future preparedness (individual)	305	13	2.67	1.35	1	5
Future preparedness (others within the community)	310	8	2.22	1.44	1	5
Future preparedness (others within the community)	311	7	2.79	1.54	1	5

5.2. *Coping ability and adaptive capacity*

The coping ability and adaptive capacity of communities and households play an important role in flood risk management [12]. In particular, aging communities need stronger support to increase their individual coping ability and adaptive capacity as these groups are usually more vulnerable toflood hazard events. The sampling confirms that the population has a large experience with floods. A majority of the respondents (75.1%) had already experienced flood events (directly or indirectly), where more than 38.7% had experienced small flood events. Most of the sampling had direct experiences with the devastating 1965 and 1966 flood events. Assessing the 2018 event, a total of 13.2% of our sampling was directly affected, where most of the damage had been agricultural and forestry products. The affected householders usually had a very fast recovery process, but the level of compensation was too low ($r = -0.704$; $p < 0.001$); however, two out of 318 respondents were not able to reach the status before the flood event. The high number of flood experiences before the 2018 event had a strong influence on the individual and community preparedness of the 2018 event, and the understanding of the risk for the community, household, and individual life.

The question of individual and community preparedness to the 2018 event is fairly given. The respondents indicate mean values of 2.45 (SD 1.29) for individual preparedness, 2.22 (SD 1.44) judgment of how others prepare and 2.79 (SD 1.54) preparedness of the public administration and blue light organizations. Overall, the respondents who had already experienced floods before 2018 had a much better preparedness than the others ($\chi2$ (5) = 23.584; $p < 0.001$). Smaller events also had an impact but were less dominant than large flood events in the past ($\chi2$ (5) = 10.821; $p < 0.055$). Additionally, the risk perception and understanding of the risk for the community and individual property were highly influenced by previous experiences (local authority: $\chi2$ (5) = 15.035; $p < 0.01$; private property $\chi2$ (5) = 33.722; $p < 0.001$; individual life $\chi2$ (5) = 15.518; $p < 0.008$). This is in line with the length of residence, as the longer the respondent lived in the village, the better the individual preparedness ($\chi2$ (5) = 17.578; $p < 0.004$), and the better the assessment of the 2018 flood event ($\chi2$ (2) = 16.183; $p < 0.001$). In addition, the membership in the fire brigade provides a slightly significant positive correlation with individual preparedness ($\chi2$ (5) = 10.370; $p < 0.065$). Surprisingly, membership had no influence on conducting concrete property-level flood risk adaptation measures or having an insurance bill against flood hazards.

Analyzing the impact of the 2018 event, we observed only a few significant changes within the community. Only the aspect of whether a household was affected by the event, was a slight significance of implementing property-level flood risk adaptation measures on private ground ($r = 0.309$; $p < 0.001$). Regarding the level of trust, we observed that flood experiences played no significant role in trust in local authorities or blue light organizations, except for individual self-capacity ($\chi2$ (1) = 6.436; $p < 0.011$), which provided a higher degree of self-preparedness ($\chi2$ (5) = 19.787; $p < 0.001$) as well as a willingness to implement property-level flood risk adaptation (PLFRA) ($\chi2$ (1) = 11.248; $p < 0.001$).

Assessing the sociodemographic factors, most of the aspects played a minor or nonsignificant role in individual preparedness. In particular, the factor of education, labor status, or place of residence had no significant impact on individual preparedness and judgment about the frequency and magnitude of future flood events. The strongest differences can be observed in the aspect of gender, where the differences played a significant role in individual preparedness ($F = 12.775$, $p < 0.000$), expectations of future events ($F = 7.064$; $p < 0.008$), and better preparation for future events ($F = 5.941$; $p < 0.015$). Surprisingly, the indicator of social cohesion (more than 56% indicated with 4 and more out of 5) played no significant role.

5.3. *Assessing current and future exposure*

This research step analyses past and future settlement development in the context of population decline (Fig. 3; Appendix 4). In St. Stefan im Gailtal or Dellach the relative changes in exposed buildings only increased by approximately 2%, in comparison to the municipality of Kötschach-Mauthen (increased by approximately 14%) between 1998 and 2019. The district shows that the number of additional buildings in areas subjected to flooding is 267. Analyzing the changes in the number of people living in the area, the number of inhabitants in Gailtal declined by 2% (between 1991 and 2001) and approximately 7% (between 2001 and 2019); the strongest declined can be observed in St. Stefan im Gailtal. This demonstrates that even though the population was decreasing, the number of buildings in exposed areas was still growing.

Analyzing future developments, we used a potential worst-case scenario that assumes that all plots that allow residential use would be built upon (Fig. 3; Appendix 5). The estimated future development shows an additional increase in the use of flood-prone areas for residential purposes in all municipalities. In Kötschach-Mauthen, for example, in the 1:300 flooding area, there would be an increase of approximately 27% of developed building land. In the area of risk – according to the hazard zone plan by the WLV – residential land would rise approximately 22%. In total, 31% (19 ha) of additional residential areas would be developed in areas sub-

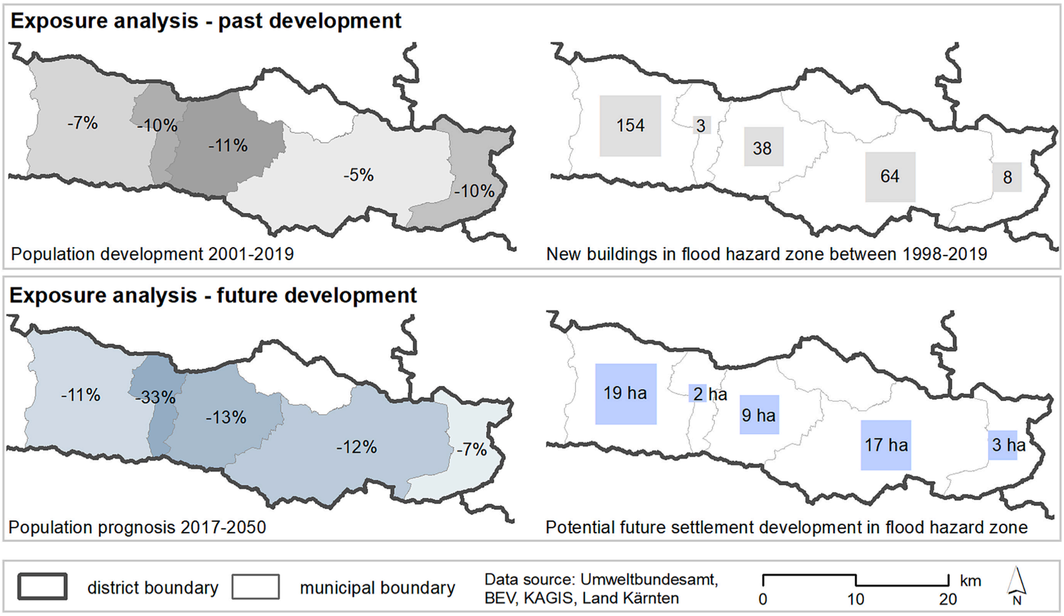

Fig. 3. Past and future development of exposed buildings and population in the Gailtal, 1998–2050.

jected to flooding in Kötschach-Mauthen. The potential rise of developed residential land in flood-prone areas can be observed in all municipalities. However, the potential future settlement development in- and outside flood prone areas is evolving in a similar proportion. Currently, approximately 21% of the residential area is located in flood-prone areas. In the potential future scenario, even though the total amount of hectares of residential areas is rising, approximately 21% would still be located in flood zones.

In all examined municipalities, the potential future development predicts an additional increase of residential areas exposed to flooding; in total it amounts to 50 ha in the whole study site. However, the population prognosis states a decrease of 13% for the study site between 2017 and 2050. Examining a region experiencing population decline shows that the increase in exposure is not necessarily coupled to the population trend. Therefore, the amount of buildings exposed to flooding can increase while the population is declining, leading to an increase in flood risk. Settlement development in flood-prone areas can be due to multiple reasons.

The development of residential areas was and is taking place inside and outside of flood-prone areas. In the district of Hermagor, the number of buildings is increasing even though the population is not growing; however, the number of one- or two-person households rose by 6.5% between 2011 and 2017, while the number of households with three or more people decreased by 6.8%. In addition, the available area for permanent settlement can influence the development in flood-prone areas. In Dellach, for example, only 9% of the permanent settlement area was affected by flooding in comparison to 24% in Kötschach-Mauthen, which is reflected by the difference in additional buildings in those municipalities (an additional 3 buildings in Dellach and 154 buildings in Kötschach-Mauthen).

5.4. Public flood risk management strategy in the Gailtal

The structural regulation of the river Gail started in 1875. The riverbed was deepened and large-scale meliorations were carried out. The land gained through regulation was enormous. Since the "General Project 1935″, large forelands have been used as flood retention areas to reduce and control flood discharge. A successful concept, which was further optimized in the "General Gail Expansion Project 1970″ and is still valid today: settlements and important transport links are protected by dams up to a hundred-year flood. Extensive retention areas ("retention basins") ensure delayed runoff in the event of catastrophic floods in the surrounding area and protect the settlement area from flooding. The costs of the flood protection investments made between 1971 and 2008 as part of the "General Project 1970″, consisting of new constructions, emergency measures and maintenance, accumulate to approximately EUR 60 million according to the capital stock analysis [52]. Between 2000 and 2013 the Carinthian Water Management (BWV) and the Torrent and Avalanche Control (WLV) promoted and supervised flood protection measures with a total volume of approximately EUR 25 million annually, financed by the federal government, the state and interested parties [53]. In 2018 and 2019, annual investments were between EUR 30–35 million. This includes expenditures for flood protection dams, retention basins, planning measures and runoff studies. The applicants (interested party) for the subsidies are predominantly municipalities or water associations as developers of flood risk management projects.

In recent years, several flood risk management projects have been realized in the case study region. The first project started after the 2003 flood event in the municipality of St. Stefan. The project was under the supervision of BWV. The total costs of the project amounted to EUR 5.1 million and was completed in 2013. Additionally, the WLV invested approximately EUR 9 million. Through the lowering and widening of the channel, the flow rate of the Vorderbergbach was significantly increased, while the structural measures of the WLV aimed to protect the village from solids and wood debris. A second large protected was successfully completed in

Kötschach-Mauthen in September 2017 (total investment volume of EUR 11.5 million). By widening and deepening the river profile, with the installation of safeguards and raising the banks, protective measures were implemented over a length of almost 3 km. As a result, Kötschach-Mauthen will be protected against a 100-year flood in the future. Third, in September 2020 a new flood risk project started in Hermagor. After ten years of discussion and preparation, the widening of the Gail tributary Gössing will take place. To be able to cope with the increased runoff volumes, longitudinal structural measures as well as a retention basin of approximately 500,000 cubic meters will be built. A total of EUR 13 million will be invested. In addition, risk management plans including flood hazard and risk maps were formulated for three municipalities in the region (Hermagor, Kirchbach, and Kötschach-Mauthen) in 2015. Nonstructural flood protection measures such as early warning systems, public information and education as well as disaster response plans are included in those risk management plans.

This overview showed that over the timespan of 50 years considerable public funds have been used for flood risk management measures in the Gailtal region. The justification may lie primarily in enabling economic development in an otherwise highly vulnerable region. However, demographic change could require a strategic rethinking of this strategy. Three impacts of demographic change on flood risk management were highlighted in the expert interviews: (1) The water management authorities in Carinthia used the population development until 2030 as an indicator to identify areas with significant flood risks [54]. (2) Demographic indicators have never been knockout criteria for the financing of flood projects until now, even when their cost-benefit ratio is not adequate. Rather on the contrary, there is a high political will to support rural areas. However, the communities are aware of the threat that funding might end sometime because of the population decline, and they are very afraid of this. (3) Another issue is the maintenance of the existing protective structures to uphold the current protection level because the financial burden might become too high for communities with population decline.

5.5. *Policy discourse*

First, the collection of publicly conveyed positions and narratives in the fields of flood risk management and demographic development helps us to compile a chronology and come up with a first *reading of events*, enriches the description of our case study region, and, in combination with the preceding literature, provides us with a brief *overview of the field* [5]. show that the Austrian flood risk management policy is aware of both major demographic developments and new challenges for flood risk management. However, this does not mean that any relations between them are established. The *structuring concepts, ideas, categorizations, and story lines* in this field confirmed this impression. The public administration at the state level is aware of major demographic challenges, as proven by the State of Carinthia's development strategy for governmental and administrative action until 2025 [55]; p. 6f). In addition, a series of strategies, concepts, and master plans address the particular exposition to impacts of climate change (including heavy rain and floods) ([55]; p. 9). However, the concepts, ideas and story lines structuring the relevant discourses in the four years following the development strategy do *not* suggest that any of the discursive actors were considering the connection between both issues. On the other side of the same coin, the analysis of regional and local newspapers as well as flood risk management plans shows that flood risk management is also a very one-dimensionally discussed issue. With a very few exceptions, flood risk management exclusively focuses on structural measures without any consideration of demographic changes.

The analysis of the so-called *sites of argumentation*, which is supposed to reveal the positioning effects of relevant institutions and actors, key incidents, and discursive practices, shows a similar picture. Accordingly, demographic challenges are an issue (e.g., the necessity to improve local infrastructure as incentive for young families to stay; the demand for affordable living space). The same is true forflood risk management. However, both issues are, again, not related to each other, and the focus regarding flood risk management is both at the local and regional levels on structural measures. In contrast to the positions of local politicians, at the state level, there are at least a few hints regarding the connection of both issues. This can be seen in the protocols of the state's parliamentary debates and state government meetings, which document debates regarding an increase in fire fighters' age limits, a stronger consideration of demographic factors, the acknowledgment of fire brigades' struggle in rural areas with staff shortages on workdays (47th session, 4/28/2016; 8th session, 10/25/2018), or a stronger consideration of the increasing number of secondary residences and urban sprawl for flood risk management (22nd session, 10/24/2019). However, overall demographic change appears to be a rather marginal issue. The only actual action remains a unanimous decision to hold a symposium on “The demographic development of Carinthia” (19th session, 6/13/2019). Regarding flood risk management in particular, the debates are full of appraisal for the work of voluntary emergency services and proposals to support and reward their work. The members of parliament criticize the state's poor spatial planning and discuss ways to support victims of the flood. However, again, the actual practices following from this awareness are the announcement of a symposium dealing with an increase in weather-related damages and the resulting political challenges (10th session; 11/13/2018), the provision of financial assistance for flood water protection projects (EUR 7.675 million) (12th session; 12/12–14/2018), the modification of awards for volunteers (14th session; 1/31/2019), and the permit to give volunteers priority for admission into the public service and obtain particular privileges (20th session; 7/18/2019). Overall, even though at least a few links between flood risk management and demographic developments are argumentatively established, those practices do not represent any serious policy changes. The large number of flood protection projects that are co-financed or otherwise supported by the state (e.g., through the provision of state-owned properties) proves the focus on purely structural measures. Other measures, such as financial support of businesses whose employees support voluntary emergency services or funds for the reparation of damages, are only ad hoc measures, which do not result in any structural changes.

6. Discussion and conclusions

Sociodemographic change has an impact on the current flood risk management policy across the globe [5,12]. Key impacts reflect the vulnerability and development of exposed residential and nonresidential buildings and people as well as the implementation of risk reduction measures [5,9,56]. Shrinking municipalities (usually with a higher percentage of elderly people) usually show a higher social vulnerability and higher risk of social exclusion in terms of flood risk management in comparison to economically prosperous regions [6,12,14,57]. In particular, the decision-making process within flood risk management is often based on the assessment of physical damages and the number of people at risk [14,58]. Such a number-of-people perspective favors economically prosperous regions with an increased number of homeowners and businesses in contrast to shrinking municipalities.

The assessment of households of the selected municipalities in the Gailtal showed this threat of being excluded from the Austrian flood risk management system. However, our analysis uncovered a different situation than we expected based on ongoing debates in the related literature [12,59,60]. First, the selected municipalities show a high coping ability and capacity to react to the threat of flood hazards. Because of their social network within the municipalities and neighborhoods, risk awareness and perception of the householders, preparedness within these municipalities is rather high. This implies that rural (shrinking) municipalities in the selected study region are less vulnerable. This finding differs from studies conducted by Refs. [61–63] were actually older people and their social networks encouraged vulnerability instead of reducing it. The present study emphasizes that risk awareness, risk perception and coping capacity are still influenced by the 1965 and 1966 extreme flood events in the region. The sampling shows that people developed their coping capacity based on the 1965/1966 events. In thi stufy, flood memories are an important factor for risk communication and the development of resilience in rural areas [64,65].

A second key finding of the study reflects the question about the relationship between demographic change and exposure [66–68]. The results do not support the hypothesis that shrinking municipalities lead to a decrease in exposed buildings (similar to Ref. [29]. The study demonstrated that there exists a decoupling effect between population growth and exposure, the so-called exposure paradox. Possible reasons for this paradox are: (a) the decreasing number of persons per household; (b) political decisions as the mayor and local authority try to provide attractive and low-cost land to build new and more residential and nonresidential buildings within the municipality, especially in the case of a shrinking process. However, these new developments are often in hazard-prone areas; and (c) the zonation of the building plot was conducted in the past (e.g. in the 1950s–1970s) without the restriction of designed hazard-zones. Usually, hazard information is provided at a later stage, often 20–30 years after zonation. However, the land owner developed the building plot between the years 2000 and 2019, as there are no building regulations in Carinthia to develop the project after a certain time period; or (d) the increasing number of second-home residents in the rural countryside influenced the increasing number of exposed buildings in the region. The population movement is highly induced by 'new immigration' or amenity migration (so-called new highlanders) of wealthy-retired families in the region [69]. The failure to detect the exposure paradox encourages damage potential in shrinking municipalities. In addition, this exposure paradox also encourages urban sprawl processes in the Alps [70].

Finally, there is currently no shortage in financial means for flood risk management and setting priorities among flood projects. To date, demographic indicators have never been knockout criteria for the realization of flood projects. In contrast, there is a high political will to support rural areas at the national, regional and local levels [5]. The results show that demographic change is currently not a major issue in Austria's flood risk management, while the majority of experts expect this to change in the future. Flood risk management strategies are organized on the current socioeconomic and hydrological assessments and do not explicitly consider future developments, such as demographic change [71]. However, the constant threat of demographic change is somehow acting as a "Sword of Damocles" for decision-makers at the regional and local levels. Rural regions know the challenge of demographic change and the challenge of providing social infrastructure, such as schools, hospitals, roads, or train stations. Such challenges also influence flood risk management. A key issue is the maintenance of the existing protective structures to uphold the protection level. The Austrian Torrent and Avalanche Control System (WLV) alone has built approximately 250,000 protective structures in Austria in the last 100 years using a wide variety of materials and construction methods. The maintenance of these protective measures currently accounts for approximately 50% of the annual budget of the Austrian Torrent and Avalanche Control System. The core question is therefore not whether to generate new protective measures on a large scale in the future, but how to maintain the current level of protection. In addition, the water management authorities in Carinthia also used the population development until 2030 as an indicator to identify areas with significant flood risks. They also take into account demographic factors to make decisions on specific flood protection projects in municipalities. For instance, if enough personnel resources are available to install mobile food protection walls under the condition of short early warning times or if the local fire department truly has the technical skills to operate a fully automatic retention basin.

The results of our case study do not support the assumptions presented in the literature: (a) that aging householders are clearly more vulnerable and have less coping and adaptative capacity in comparison to younger generations, (b) that aging communities usually show a shrinking development of the population, which often results in a lower risk of increasing exposed buildings in the floodplain, and (c) that shrinking communities also usually reach a lower cost-benefit ratio, which means less financial support by the national or regional authorities. The results of our case study show an image that is clearly at odds with the general assumptions we find in the literature. One possible explanation might be that the general academic debate about vulnerability and age is strongly based on studies conducted by American researchers in the 1990s and early 2000s (e.g., Refs. [6,59]. These researchers often predefined age as increasing vulnerability with the result that shrinking communities are more vulnerable than prosperous communities [26,72]. In addition, age is usually calculated by census data (e.g. Ref. [6], without reflecting the complexity behind it.

However, this might change in the near future within our case study region, if most of the householders are older than 80 + years. Here, we might observe a tipping point at the local level if a large amount of the municipality is older than 80 +, and how the householders might react to extreme weather events. The results of the study raise the challenge that shrinking communities are afraid of the aspect of population decline and of being excluded from future risk reduction measures. The results of the study show that is not possible to draw simple conclusions regarding the causal effects of demographic change on flood risk management, as the impacts of demographic change are far more complex. This also reflects the need for more quantitative and qualitative studies to understand the interlinkages between age, vulnerability, coping ability and adaptive capacity, exposure and risk management strategies.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Further data of this study can be found in the supplementary material

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Appendix A. Supplementary data

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