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Damage assessment of lake floods: Insured damage to private property during two lake floods in Sweden 2000/2001

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ABSTRACT

This study analyses empirical data on the direct damage impact of lake floods using insurance claims for 195 private buildings. A relationship between lake water levels and insurance payments is established, but the estimated economic effects are small. Building damage also occurs in fringe areas that are not reached by surface water, which indicates a complex interplay between several factors influencing the degree of damage. Large lake floods occur over an extended time span (months). Their duration, as well as possible wind effects, should be taken into account in flood risk assessment. The slow onset of lake floods facilitates implementation of private damage-reducing measures in addition to public mitigation efforts. Private damage-reducing measures decrease the risk of structural damage to buildings, easing recovery for homeowners and society as a whole. Insurance companies can gain from investing in public flood awareness programmes and by providing information to their insurance holders on how to reduce property vulnerability in emergency situations.

1. Introduction

Northern Europe is expected to experience increasing flood implications in the future [1]. A flood is a temporary covering of land by water as a result of surface waters escaping from their normal confines or as a result of heavy precipitation [2]. Flood disasters are the result of interactions between hydrological floods and societal systems [3]. In quantitative risk assessment, risk is defined as the probability of being exposed to a flood and the expected damage [4]. Expected damage is the product of damage potential and its corresponding vulnerability, where vulnerability depends on the susceptibility of elements at risk and on property owners' ability to recognise risk and thereby to protect their property [5,4]. The degree of exposure depends on hydrological and meteorological characteristics of the water body and the weather conditions during the flood. Society's vulnerability to flood hazards has underlined the need for risk mapping and measures to mitigate the consequences of such events. Damage to buildings accounts for a considerable share of total monetary damage caused by floods [6,7]. A review of damage in the aftermath of the flooding of Elbe 2002 showed that 62% of the direct damage cost was caused by damage to buildings [8]. Knowledge about how residential areas are exposed to lake floods and their vulnerability when exposed is important in order to develop effective mitigation strategies [9].

Numerous factors are suspected to contribute to flood damage. These factors include water depth; flow velocity; duration of inundation; contamination; sediment or debris load; building construction, age, and materials; warning time and

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previous experience with flooding [10,11–13]. In addition, coastal flooding generally brings strong wave action [11]. The most frequently used approach to assess the direct costs of damage to buildings is the application of damage functions, also referred to as stage damage functions, vulnerability functions or depth damage functions [14–17,11,12,18]. Damage functions are based either upon empirical or synthetic data [19,16] and say something about the vulnerability of assets to certain flood and building characteristics [20]. Damage functions most often only consider maximum water levels as the only damage influencing factor [21]. The water level is assumed to be slow-rising, which implies that there are no hydrostatic pressure differentials between the inside and the outside of a building [22]. Extensive research on UK flood damage has resulted in several manuals (blue manual, red manual, multi-coloured manual). In addition to flood depth and land use categories, the UKs damage functions also consider flood duration. A short duration is less than 12 h, and a long duration is 12 h or more [22]. Very long flood durations (over one week) are associated with increased physical damage compared to that from a short duration [23].

The value of hazard mitigation lies in avoiding damage and loss [24]. To be able to prevent flood damage, knowledge of the potential significance of flood characteristics is needed [22]. The uncertainty in predicted flood risk to a large extent depends on the uncertainty in damage modelling and less so on the uncertainty in estimated hazard probability [25,5]. Assessment of economic consequences is constrained by limitations in available data [19]. There is no comprehensive or standardised single database for flood disasters in Europe, or a database including accurate and detailed data of the flooded areas for both recent and historical events [2]. Currently, the most comprehensive loss databases are held by insurance companies and are not publicly available [26]. Datasets of past events are a useful tool as they give an idea of possible affected areas, expected magnitude of events, their frequency and possible impacts on vulnerable elements [27].

According to a study performed by Gothmann and Reusswig [28], self-protective behaviour by residents of flood-prone urban areas can reduce monetary flood damage by 80% and reduce the need for engagement from rescue services in emergent flood risk management. Private damage-reducing measures, e.g., the building of temporary barriers, can be effective in preventing damaging water depths from reaching a building. Other measures such as moving house inventories out of the reach of the water can reduce the extent of damage even though the building may be adversely affected. Adequate and timely information distributed by authorities to inhabitants during a flood is of great importance for successful mitigation actions [29].

The objective of the study is to analyse buildings' exposure and vulnerability to lake floods using historical lake flood events and their associated insurance payments.

2. Case study – lake Vänern and lake Glafsfjorden

Extensive and prolonged flooding occurred in south Sweden from autumn 2000 until spring 2001 along Lake Vänern and Lake Glafsfjorden. Lake Glafsfjorden (94 km^2) is situated in the River Byälven catchment upstream to the large Lake Vänern (Fig. 1). A prolonged period of excessive precipitation in 2000/2001, about three times normal, substantially increased water input to the lake, exceeding its outflow capacity and causing slowly rising lake levels. Lake Glafsfjorden reached its highest level on November 29, approximately 3 m above its normal level. The municipality of Arvika, which has approximately 26,000 inhabitants, was partly flooded. An extensive emergency operation, which lasted for about a month and a half, was launched to counteract the flood impact. Temporary barriers several kilometres long were built in the central part of the town, initiated by the authorities as public measures. Apart from damage to numerous private buildings along the lake-shores, several roads had to be closed and railway traffic was cancelled for more than three weeks. The costs for the flood were estimated at SEK 315 million (2009 price levels) (34 million EUR), out of which damage to buildings amounted to approximately 28% [30]. The flooding of Lake Glafsfjorden ranks as the most severe flood in Sweden in modern times.

With its 5650 km^2, Lake Vänern is the largest lake in Sweden and the largest lake within the European Union [31]. Lake Vänern has several inflows, but the river Göta Älv is the only outflow. The Göta Älv River is ca. 93 km long and flows from the lake outlet near Vänersborg to the city of Gothenburg by the North Sea. The mean discharge to the sea is 565 m^3 s^{-1} [32]. Due to water regulation, the maximum discharge from the lake is 1030 m^3 s^{-1} [31]. The outflow is limited due to landslide risks along the densely populated river valley and the flood-prone location of the city of Gothenburg. Lake Vänern and the Göta Älv River are used for hydropower production, shipping, tourism, recreation, fishing, drinking water supply, and as recipients of waste water from municipalities and industries, etc. [31]. Seven cities are located by the lake (Fig. 1) but damage occurred in both rural and urban areas. 260,000 Inhabitants live in the municipalities bordering Lake Vänern. No effort has been made, within this study, to identify the number of inhabitants living in close vicinity to the lake and thereby having exposure to flood risk. Due to the slow dynamics of Lake Vänern, the duration of a flood is likely to be long. During the flood 2000/2001, water levels remained high for several months from November 2000 to June 2001. The lake reached its peak on the 11 January 2001, 1.3 m above its normal level, which is the highest level since the lake was regulated in 1937 [33]. The return period for a level this high has been estimated by Swedish Meteorological and Hydrological Institute (SMHI) at 100–150 years. Despite public preventive measures, many locations around the lake were affected by damage to buildings, water utility systems and roads. In particular, the impact was large on recreational facilities such as campsites, boat marinas and harbours. Approximately 2000 ha of agricultural land were flooded and forestry and fishing industries suffered damage [34].