Pluvial flood damage cost analysis

Case study Trelleborg, Sweden

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Highlights

- Employs detailed micro-level pluvial flood damage data.
- Evaluates the relationship between multiple attributes such as flood depth, rainfall data and pluvial flood damage cost.
- Identify statistical correlation between flood damage cost and rainfall amount.

Introduction

Extreme rainfall events have been increasing in frequency and intensity, posing significant challenges to urban areas. It becomes important to understand the underlying characteristics and drivers that contribute to flood damage in order to formulate preparedness strategies. This study is designed to investigate these complexities by collecting and analyzing flood damage data in the city of Trelleborg, Sweden.

The scarcity of detailed pluvial flood damage data has hindered in-depth investigations on the reasons behind the flood damage. Some examples are the studies that Grahn et al. 2017, carried out that examined 2140 individual observations of insurance payouts for residential buildings caused by 49 different rainfall events in Sweden and another study which used insurance claims between 1987 till 2013 with 304 data observations.

In our research, we delved into the comprehensive historical flood damage claims recorded between 2006 and 2022, with their precise spatial location in the city of Trelleborg, a coastal city situated in southwestern Sweden. This dataset presents an interesting possibility to explore the factors influencing the correlation between flood damage cost and number in relation to variables such as sewer type connections, flood depth, and rainfall data. Notably, in Sweden, property have the option to seek compensation for flood-related damages through their municipal water and wastewater utility which made this study possible. (Mobini, 2022).

Methodology

We examine a multitude of factors that might influence flood damage, focusing primarily on rainfall metrics and property-specific characteristics. This approach offers understanding of how the attributes of rainfall events correlate with the extent of flood damage. Additionally, we look into property-related attributes such as age of construction, drainage systems and flood depth to see how they contribute to the damage cost.

1. Statistical analysis
   Linear regression analysis is used to predict the number of flood damage cases based on the value of rainfall amount. R-Squared (R^2 or the coefficient of determination) is calculated to determine the proportion of variance in the dependent variable (flood damage cases) that can be explained by the independent variable (rainfall).
2. Machine learning analysis

In the next step, machine learning techniques will be implemented to further investigate the relationship between flood damage cases/cost and potential factors, including property-related attributes, rainfall amount and flood depth.

Classification and Regression Tree (CART)

CART is a supervised learning approach to map between the target variable and corresponding input variables. Feature importance can be derived from the tree for each input and therefore the most influencing variables can be identified. In our case, CART will be applied for both flood damage case numbers and flood damage cost as target variables, and investigate their drivers accordingly.

Case study

The city of Trelleborg is located in the southwest corner of Sweden. The city has a historical problem with pluvial flooding in particular basement flooding from the sewer system. The urban drainage system of the city is mostly separated sewer system but there are around 3% combined sewer system which puts the city vulnerable during the heavy rainfalls. These data were obtained via search in the archive of the Trelleborg municipality. The available data is from 2006 till 2021 which is presented in table 1. We obtained rainfall data as an average daily data from the Swedish metrological institute (SMHI). There are several variables which have been registered on each case but it is not homogenous for all the cases. The variables are, flood depth in the basement of the property, the damage cost, the date of the flood event, the age of the property, the type of sewer system that the property is connected to.

Results and discussion

The analysis of the historical flood damaged properties which was collected from the Trelleborg water and wastewater utility is shown in table 1. This provides our initial insight into the primary rainfall event responsible for the majority of damaged properties, which belongs to the flood event on the 2010 which resulted in 355 damaged properties. Daily rainfall data are obtained from the open dataset from the Swedish Meteorological and Hydrological Institute for the corresponding events.

Table 1. Number of damaged properties in relation to flood event

Flood events	Number of reported damaged properties
2021-07-16	67
2019-06-12/15/20	39
2019-07-28	18
2018-08-10	14
2016-06/07/08	41
2010-08-17	355
2007-07-05	42
2007-08-11	29
2006-08-02	199

Figure 1 shows the daily rainfall for the corresponding events, and the regression analysis between the number of damaged properties in relation to the rainfall amount on the reported date, maximum daily rainfall during the rainfall event, total rainfall of the event. Here the corresponding rainfall event is defined as a continuous rainy day (over 0.1 mm) of the nearest proper event (over 1 mm) until the reported damage date. From the regression, R^2 between reported flood damage case numbers with rainfall on that date has a relatively small correlation around 0.4 (0.3988, green dotted line). While including the maximum daily rainfall, the correlation gets stronger to 0.63 (0.6299, orange dotted line). An even higher correlation is identified when associating flood damage cases with the total rainfall amount, as showed by purple dotted line with R^2 0.7098. This indicates the flood damage in Trelleborg is a consequence of accumulated rainfall in a longer time scales covering several days.

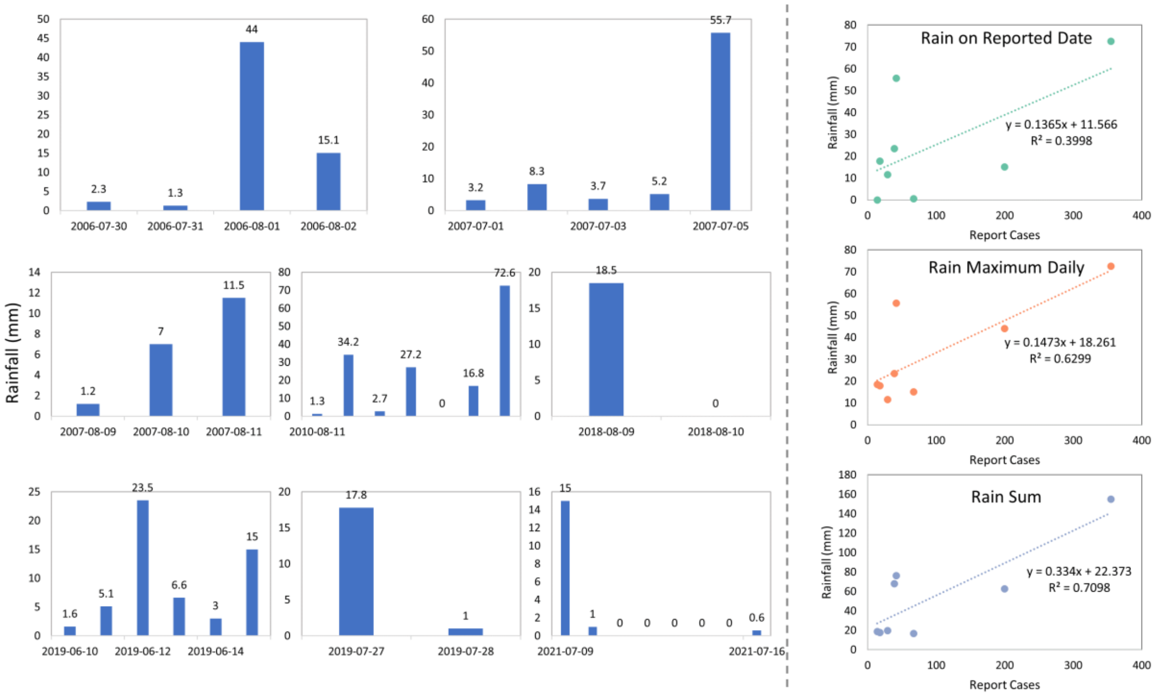

Figure 1. Rainfall event before the reported date and correlation between reported cases with rain-on-reported date; maximum daily rainfall during the event; total rainfall of the event.

In total during 2006 to 2021, in Trelleborg, there are 806 cases reported. Average flood damage cost is 56000 SEK, with median 22048 SEK in 190 cases (Figure 2). The interquartile range is between 10000 SEK up to 60000 SEK, indicating a considerable uncertainty. This further strengthen our research need where detailed investigation is needed to enhance the preparedness for flood damage.

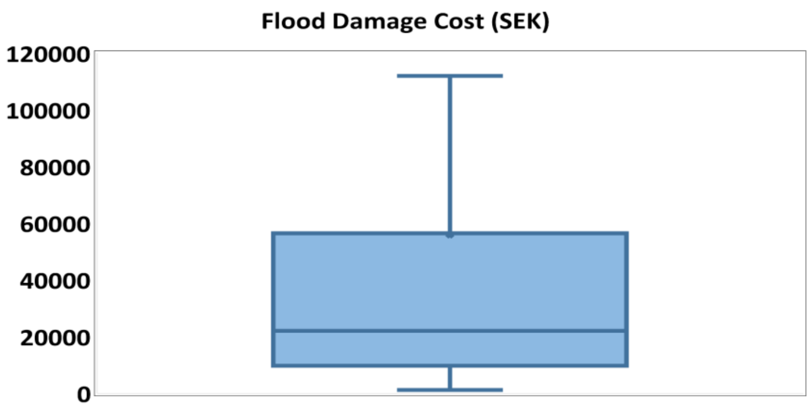

Figure2. Boxplot of flood damage cost in Trelleborg

Conclusions and future work

Our findings aim to provide actionable insights for the municipality as short-term reactive measures for extreme events, as well as long-term planning, such as infrastructural upgrades and zoning regulations, to improve community resilience.

This research underscores the significance of high-resolution flood damage data, emphasizing its ability to unveil more precise relationships that clarify the variations in damage costs. The findings emphasize the necessity for systematic flood damage data encompassing additional variables, particularly detailed damage costs. This initial outcome establishes a connection between rainfall data and the count of damaged properties, paving the way for future analyses. Subsequent stages of this study will involve statistical analyses and machine learning techniques to further explore correlations with other variables, including flood depth in the basement and the age of the building, in relation to damage costs.

References

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