DELIVERABLE D.T. 5.1.2

# Joint questionnaire on flood impact data

EMfloodResilience

INTERREG Euregio Maas-Rijn | Project No. EMR228

The EMfloodResilience project is being carried out within the context of Interreg V-A Euregio MeuseRhine and is 90% funded by the European Regional Development Fund.

| | |
|---|---|
| **Dissemination level** | Public |
| **Type of deliverable** | Report |
| **Work package** | WP5 |
| **Deliverable number** | D.T5.1.2 |
| **Status - version, date** | V2, 31/10/2023 (Final) |
| **Deliverable leader** | **Liège University**<br>Ir. Daniela Rodriguez Castro<br>Prof. Benjamin Dewals |
| **Deliverable contributors** | **RWTH Aachen University**<br>Dr.-Ing. Elena-Maria Klopries<br>Eva Vonden, M.Sc.<br>**Delft University of Technology**<br>Prof. Dr. ir. Matthijs Kok<br>Ir. Nils van der Vliet |
| **Contractual date of delivery** | 31/12/2023 |
| **Keywords** | Flood impact data, flood damage survey, flood damage, flood loss, damage function |

## Acknowledgement

The authors express their gratitude to over 200 respondents who participated in the field surveys.

The leaders of the Deliverable extend their thanks to D. Molinari, A.R. Scorzini, and H. Kreibich for engaging in valuable scientific discussions on the topic.

Recognition is also given to the colleagues who played a crucial role in conducting interviews. Special acknowledgments go to Elisa Praud and Lisa Djanaralieva from the Belgian team for their assistance in the research. In Germany, Celvien Lee, Benedikt Bröcker, and Zoe Boller are appreciated for their support. Lastly, in the Netherlands, the authors are thankful for the contributions of Cédric Maas, Vita van Steen, Britt Coenen, Lars Marx, Julian Stassen, and Stef Lemmens.

**Legal Disclaimer**

# Table of contents

## List of figures

## List of tables

# Executive Summary

Mid-July 2021, large parts of western Germany and the Benelux countries were hit by persistent and heavy rainfall, which led to widespread flooding that not only killed and injured hundreds of people, but also caused damage to buildings and infrastructure in many places.

The aim of the EMfloodResilience project, which is being carried out by various institutions from Belgium, Germany and the Netherlands, is to contribute to improving flood management in the Euregio Meuse-Rhine and thus reduce flood impacts. As part of this project, the study presented here, which is being carried out by the University of Liège, RWTH Aachen University and TU Delft, aims to collect data on the effects of flooding in order to evaluate and improve the existing flood damage models used so far. A field survey of affected households was undertaken.

To achieve this goal, a questionnaire with almost 100 questions was developed and translated into French, German and Dutch. Adapted to the respective population groups, each of the universities developed its own strategy for recruiting participants for the survey. These took place in person at the participants' homes and were recorded on paper. At least 70 interviews were conducted in each of the three countries.

To ensure the quality of the data, each survey was registered twice in a computer system and both entries were automatically compared with each other to detect and correct errors. The data was then statistically described and is presented in this report in the form of various graphs.

The results provide initial insights into the vulnerability, risks and damage caused by the floods in July 2021, revealing both similarities and differences between the countries.

With over 200 surveys and the methodology of double encoding, a high-quality and comprehensive cross-border data set on flood impacts was gathered. In addition to the initial findings from the descriptive statistical analysis, this report can contribute to improving the understanding of floods damage mechanisms and guide the design of risk reduction measures.

# Résumé

À la mi-juillet 2021, une grande partie de l'Allemagne de l'Ouest et du Benelux a été frappée par des précipitations intenses et persistantes, ce qui a entraîné des inondations de grande ampleur qui ont non seulement tué et blessé des centaines de personnes, mais aussi endommagé des bâtiments et des infrastructures en de nombreux endroits.

L'objectif du projet EMfloodResilience, mené par diverses institutions belges, allemandes et néerlandaises, est de contribuer à améliorer la gestion des inondations dans l'Euregio Meuse-Rhin et de prévenir ainsi des dommages d'une telle ampleur. Dans le cadre de ce projet, l'étude présentée ici, réalisée par l'Université de Liège, l'Université RWTH d'Aix-la-Chapelle et la TU Delft, vise à collecter des données sur les conséquences des inondations afin d'évaluer et d'améliorer les modèles existants pour estimer le dommages causés par les inondations, tels qu'utilisés actuellement. Une enquête de terrain auprès de la population affectée a été mise en place.

Pour atteindre cet objectif, un questionnaire comportant près de 100 questions a été élaboré et traduit en français, en allemand et en néerlandais. Chaque université a développé sa propre stratégie de recrutement des participants à l'enquête, adaptée aux différents contextes. Les entretiens se sont déroulés en personne au domicile des participants et ont été consignés sur papier. Au moins 70 entretiens ont été menés dans chacun des trois pays.

Pour garantir la qualité des données, chaque enquête a été numérisée deux fois et les deux entrées ont été comparées automatiquement afin de détecter et corriger les éventuelles erreurs d'encodage. Les données ont ensuite décrite d'un point de vue statistique et sont présentées dans ce rapport sous la forme de graphiques.

Les résultats donnent un premier aperçu de la vulnérabilité, des risques et des dommages causés par les inondations de juillet 2021, révélant à la fois des similitudes et des différences entre les pays.

Avec plus de 200 enquêtes réalisées et un double encodage systématique, une base de données transfrontalière de haute qualité et multifactorielle sur les impacts des inondations a été générée. Outre les premiers résultats de type statistique descriptive, cette étude peut contribuer à améliorer la compréhension des impacts des inondations et orienter la conception de mesures de réduction du risque.

# Zusammenfassung

Mitte Juli 2021 wurden weite Teile Westdeutschlands und der Benelux-Staaten von anhaltenden und immer wiederkehrenden Starkregenfällen heimgesucht, die zu einem großflächigen Hochwasser führten, bei dem nicht nur Hunderte von Menschen starben und verletzt wurden, sondern auch vielerorts Schäden an Gebäuden und Infrastruktur entstanden.

Ziel des Projekts EMfloodResilience, welches von verschiedenen Institutionen aus Belgien, Deutschland und den Niederlanden durchgeführt wird, ist es, einen Beitrag zur Verbesserung des Hochwassermanagements in der Euregio Maas-Rhein zu leisten und damit die Hochwasserfolgen zu verringern. Im Rahmen dieses Projektes zielt die hier vorgestellte Studie, die von der Universität Lüttich, der RWTH Aachen und der TU Delft durchgeführt wird, darauf ab, Daten über die Auswirkungen von Überschwemmungen zu sammeln, um die bisher verwendeten Modelle für Hochwasserschäden zu bewerten und zu verbessern.

Um dieses Ziel zu erreichen, wurde ein Fragebogen mit fast 100 Fragen entwickelt und in Französisch, Deutsch und Niederländisch übersetzt. Angepasst an die jeweiligen Bevölkerungsgruppen entwickelte jede der Universitäten ihre eigene Strategie, um Teilnehmer für die Umfrage zu gewinnen. Diese fanden persönlich bei den Teilnehmern zu Hause statt und wurden auf Papier festgehalten. In jedem der drei Ländern wurden mindestens 70 Interviews durchgeführt.

Um die Qualität der Daten zu gewährleisten, wurde jede Umfrage zweimal in einem Computersystem registriert und beide Einträge wurden miteinander verglichen, um Fehler zu erkennen und zu korrigieren. Die Daten wurden anschließend statistisch beschrieben und werden in diesem Bericht in Form verschiedener Grafiken dargestellt.

Die Ergebnisse geben einen ersten Einblick in die Anfälligkeit, die Risiken und die Schäden, die durch die Überschwemmungen im Juli 2021 verursacht wurden, und zeigen sowohl Gemeinsamkeiten als auch Unterschiede zwischen den Ländern auf.

Mit über 200 Umfragen und der Methodik der Doppelkodierung wurde ein qualitativ hochwertiger und umfassender Datensatz zu den Hochwasserauswirkungen erhoben. Zusätzlich zu den ersten Erkenntnissen aus der deskriptiven statistischen Analyse kann dieser Bericht zu einem besseren Verständnis der Schadensmechanismen von Hochwasser beitragen und die Gestaltung von Maßnahmen zur Risikominderung unterstützen.

# Samenvatting

Halverwege juli 2021 werden grote delen van West-Duitsland en de Benelux getroffen door aanhoudende en steeds terugkerende hevige regenval, wat leidde tot grootschalige overstromingen waarbij niet alleen honderden mensen omkwamen en gewond raakten, maar die ook op veel plaatsen schade aan gebouwen en infrastructuur veroorzaakten.

Het doel van het EMfloodResilience project, uitgevoerd door verschillende instellingen in België, Duitsland en Nederland, is om het overstromingsbeheer in de Euregio Maas-Rijn te verbeteren en zo schade op deze schaal te voorkomen. Als onderdeel van dit project heeft het hier gepresenteerde onderzoek, dat wordt uitgevoerd door de Universiteit van Luik, de RWTH Aachen University en de TU Delft, tot doel gegevens te verzamelen over de gevolgen van overstromingen om de tot nu toe gebruikte overstromingsschademodellen te evalueren en te verbeteren in een onderzoek onder de getroffen bevolking.

Om dit doel te bereiken werd een vragenlijst met bijna 100 vragen ontwikkeld en vertaald in het Frans, Duits en Nederlands. Aangepast aan de respectievelijke bevolkingsgroepen ontwikkelde elke universiteit haar eigen strategie om deelnemers te werven voor het onderzoek. Deze vonden persoonlijk plaats bij de deelnemers thuis en werden op papier vastgelegd. Er werden minstens 70 interviews afgenomen in elk van de drie landen.

Om de kwaliteit van de gegevens te waarborgen, werden alle enquêtes twee keer gedigitaliseerd en beide invoeren werden met elkaar vergeleken om fouten te elimineren. De gegevens werden vervolgens statistisch geanalyseerd en worden in dit rapport gepresenteerd door middel van verschillende diagrammen.

De resultaten bieden een eerste inzicht in de kwetsbaarheid, risico's en schade als gevolg van de overstromingen in juli 2021 en laten zowel overeenkomsten als verschillen tussen de landen zien.

Met meer dan 200 enquêtes en de methodologie van dubbele digitalisering is een hoogwaardige en uitgebreide grensoverschrijdende dataset over overstroomde gebieden gegenereerd. Naast de eerste bevindingen van de beschrijvende statistische analyse kan dit rapport bijdragen aan een beter begrip van overstromingen en het voorkomen van schade door overstromingen door middel van verschillende wetenschappelijke toepassingen.

# 1 Introduction

## 1.1 Background

In July 2021, a storm front named 'Bernd' remained stationary over Europe for several days, resulting in persistent and heavy rainfall across a wide area (Junghänel et al. 2021; CEDIM 2021; MOHR ET AL. 2023). This excessive rainfall caused significant flooding along the Meuse and Rhine River basins in Belgium, Germany, and the Netherlands (enw 2021). The impact was particularly severe in the narrow valleys of the western German and the south east part of Belgium, as well as the adjacent transition zones to the lowlands (WVER 2021). Water levels in the affected villages and cities along the flooded rivers reached 2 meters or higher (Junghänel et al. 2021).

Consequently, the region experienced severe damages, leading to a total of 200 documented fatalities in Germany and Belgium (enw 2021), along with hundreds of people sustaining injuries (CEDIM 2021). Numerous houses and villages suffered damage and partial destruction. The infrastructure was also heavily damaged, further complicating the situation for both the affected individuals and the aid workers. The event represents one of the most severe catastrophes in Europe in the half last century (MOHR ET AL. 2023).

In order to prevent such extensive damages in future flood events, governments and water management professionals need to adapt and enhance all aspects of flood management. Since floods disregard national borders, the three countries of the Euregio Meuse-Rhine, connected by their river systems, must engage in transboundary and river basin-wide cooperation as a crucial step towards effective flood prevention and management (enw 2021).

## 1.2 Objectives

To enhance preparedness for future extreme flood events, the EMfloodResilience project focuses on understanding the response of rivers and streams to heavy precipitation, identifying control parameters, and assessing the implications for specific geographical regions. This project aims to develop and enhance products urgently needed by authorities and water managers in the Euregio Meuse Rhine, as demonstrated by the event in 2021, in order to mitigate the potential future impacts.

The activities required to achieve this objective are divided into six main work packages, each consisting of various deliverables. Work Packages 1 and 2 will gather meteorological and hydrological data, while Work Package 3 will focus on improving the reliability of model outputs. Work Package 4 aims to investigate the influence of transported debris and vegetation on flow patterns within the models. Work Package 5 will address both enhancements in flood damage models and the study of extreme precipitation events. Lastly, in Work Package 6, a comprehensive cross-border river management master plan will be developed specifically for the Wurm River.

To fulfil the objective, the joint questionnaire for flood impact data (Deliverable 5.1.2) plays a crucial role within Work Package 5. The primary goal of this deliverable is to collect comprehensive flood impact data.

To achieve this, a questionnaire will be employed to gather information regarding vulnerability factors such as building characteristics, as well as data pertaining to the magnitude of the danger, such as flooding depth. Interviews based on this questionnaire will be conducted in all three countries of the Euregio Meuse Rhine - Belgium, Germany, and the Netherlands. Primarily this data will be used to assess the existing flood models in the further work of the project (Deliverable 5.1.3). Additionally, a survey of this nature can provide deeper insights in the damages, recovery, response, effectiveness of risk reduction, measures and compensation experienced following the flood event (enw 2021).

## 1.3 Content

Chapter 2 provides an overview of Case study areas as well as of the flood event in July 2021 and previous studies with surveys on the event. In chapter 3 the materials and methods are described, including the setup of the questionnaire, the survey strategy, the encoding of the data and the data analysis. The study's findings are presented and discussed in chapter 4, along with a comparison to previous research on the event. Chapter 5 concludes the study by summarizing the results obtained, making recommendations for future similar studies, examining the validity of the results obtained, and providing potential prospects.

The **motivation** for the survey was described in this Introduction and is further substantiated throughout Chapter 2, which describes the **survey areas**. The **type of survey**, **sampling strategy** and overall **survey strategy** are detailed in Chapter 3. Similarly, Section 3.1 introduces the **structure and rationale of the questionnaire**, which is provided in Appendix A.

# 2 Basics

## 2.1 Case study areas

The study areas in all three contributing countries are located within the international river basin district of Meuse, which is shown in Figure 1. The area of the international river basin district is 34,347 km² (IMC 2022) with parts in France, Belgium, the Netherlands, Luxembourg and Germany (Bezirksregierung Köln 2021) and holds about 8.8 million people (IMC 2022). The Meuse originates in France, flows through Belgium and enters the North Sea in the Netherlands (Bezirksregierung Köln 2021) after 905 km (IMC 2022). The upstream part of the Meuse basin is characterised by agriculture and forestry activity, whereas the downstream part is characterised by intense economic activities and a higher population density (IMC 2022) All flooded rivers in the study area are tributaries of the Meuse.


*Figure 1: International River basin district Meuse, changes according to Bezirksregierung Köln (2021).*

An overview of the locations of the survey areas in each of the three countries is given in Table 1. The sectors surveyed in each country can also be seen in the maps reported hereafter.

*Table 1: Locations of the survey areas in all three countries and surveyed sectors.*

| | **Belgium** | **Germany** | **The Netherlands** |
|---|---|---|---|
| **Locations** | Chaudfontaine (Vaux)<br>Theux | Zweifall, Vicht, Stolberg, Eschweiler, Weisweiler | Valkenburg |
| **Sectors** | Housing | Housing and businesses | Housing and businesses |

### 2.1.1 Belgium

The area's most severely affected by the 2021 floods in the Belgian part of the Meuse basin are the watersheds of the Ourthe river, the Amblève river and notably that of the Vesdre river.

The studied area focuses on the Vesdre catchment. The spring of Vesdre river is in Fagnes de Steinley at an elevation of 605 m and flows for 72,5 km before joining the Ourthe river in Chênée at an elevation of 70 m. Its catchment area is about 700 km². The Vesdre dam in Eupen and the Gileppe dam are primarily used to produce drinking water. They also contribute to regulate the flow in the Vesdre, especially during floods. However, the flood control capacity of the dams is limited in the case of extreme events.

As shown in Figure 2 and Figure 3, the surveyed area focuses on the towns of Theux and Chaudfontaine (district of Vaux), in the Vesdre catchment, where damages were particularly heavy. In both municipalities, the flooded area extends into areas with buildings which have sustained significant damage. Schools and elderly housings were also flooded as shown in the maps.

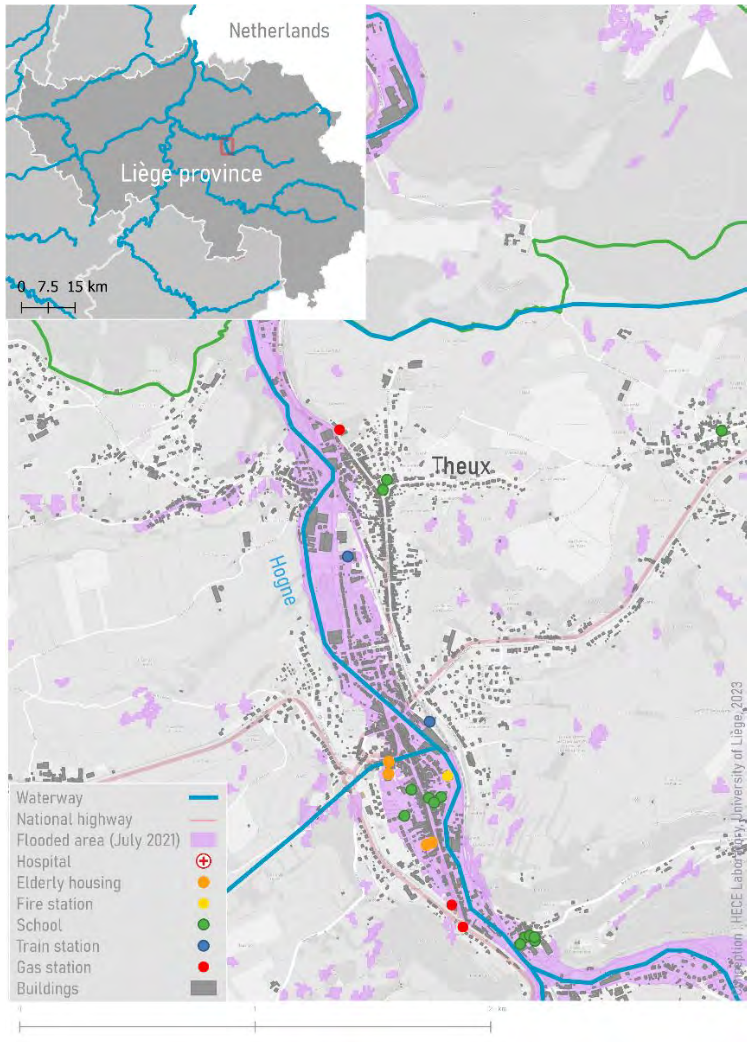



*Figure 2. Municipality of Theux. Surveyed area in Belgium.*

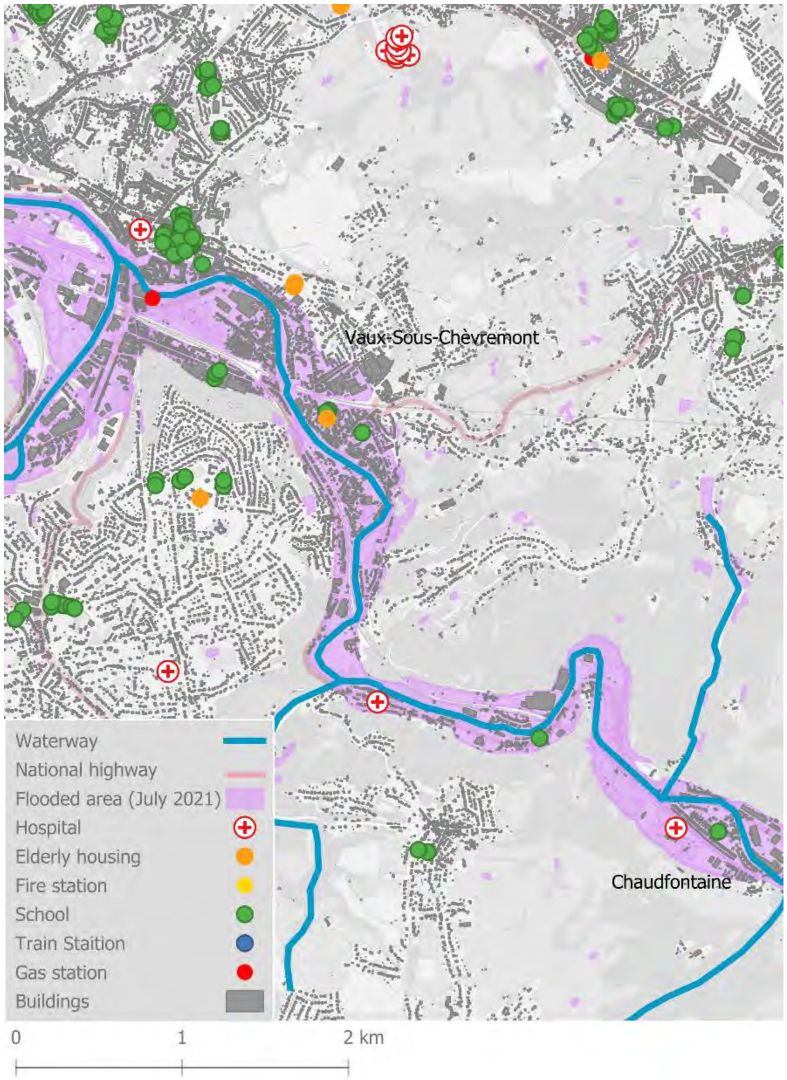



*Figure 3. Municipality of Vaux (Chaudfontaine). Surveyed area in Belgium.*

### 2.1.2 Germany

The areas that experienced the most significant impact from the 2021 flood in Germany were the Ahr Valley in Rhineland-Palatinate and some regions in North Rhine-Westphalia, including the cities and corresponding villages of Stolberg and Eschweiler, which was selected as a survey area for the purpose of this project. Both cities are part of the Aachen district, as indicated in Figure 4.

In the municipality of Eschweiler live 58,564 inhabitants (effective 31.12.2020) (Stadt Eschweiler 2023). Of this, 12,147 live in the city and 6,001 in Weisweiler (Stadt Eschweiler 2023). In the municipality of Stolberg live 57,605 inhabitants (effective 31.12.2022) (Kupferstadt Stolberg 2023). Of this, 1,798 live in Vicht an 2,045 in Zweifall (Kupferstadt Stolberg 2023).


*Figure 4: Municipalities of Stolberg and Eschweiler*

The floods in this area primarily affected the Inde River and its tributaries. According to the EU Water Framework Directive, all these rivers are located within the planning unit 'PE_RUR_1100: Inde', which belongs to the sub-basin 'Meuse South NRW’ (German: ‘Maas Süd NRW') of the Meuse international river basin district, as depicted in Figure 5. NRW lies within the north-west German climate range, which is characterised by mild winters and mixes summers in an overall warm temperate rain climate (Bezirksregierung Köln 2021).

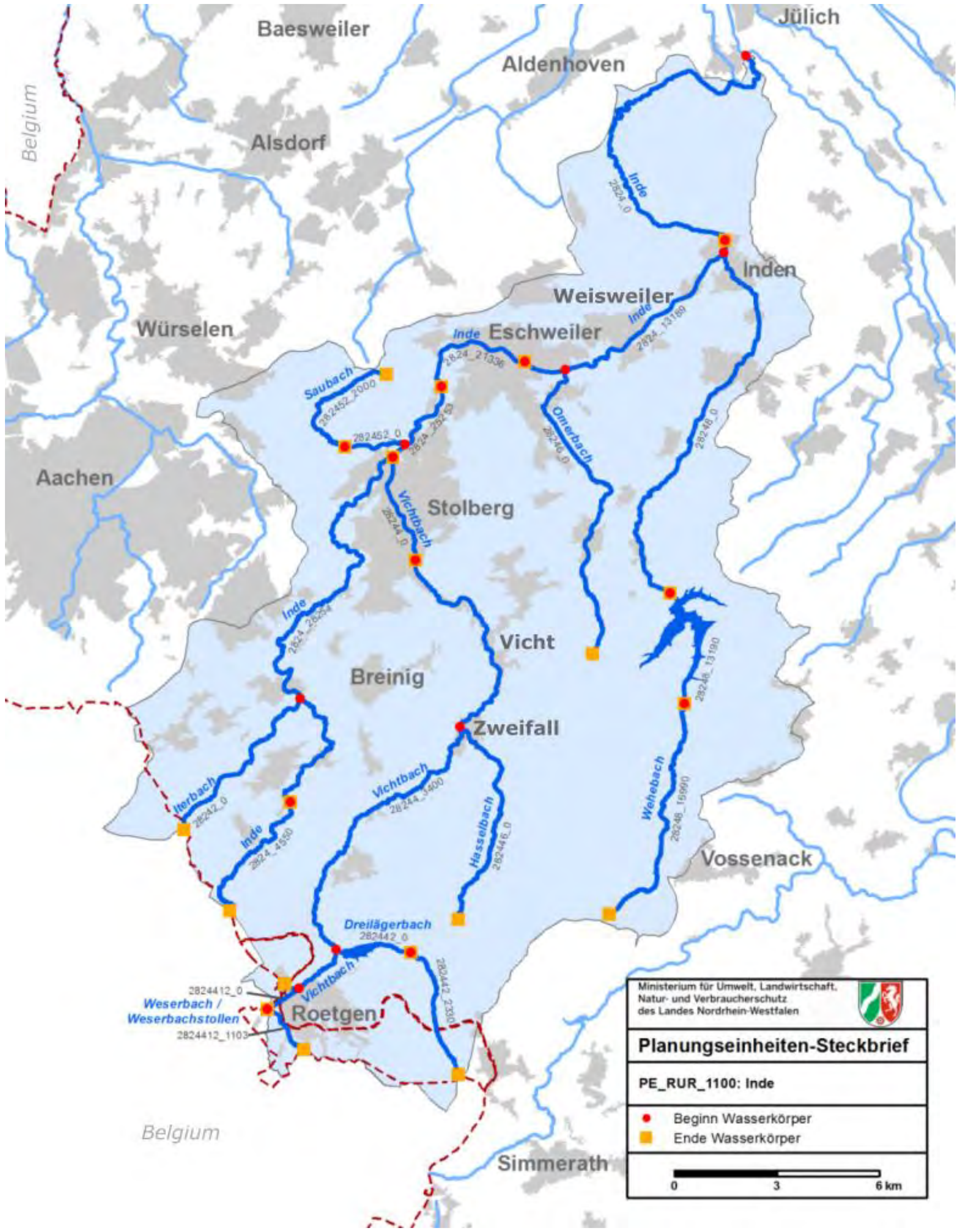



*Figure 5: Planning unit PE_RUR_1100: Inde (Ministerium für Umwelt, Landwirtschaft, Natur- und Verbraucherschutz des Landes Nordrhein-Westfalen (MULNV NRW) 2021).*

The survey areas encompass the villages and cities of Zweifall, Vicht, Eschweiler, and Weisweiler. Therefore, the rivers of particular interest in these areas are the Vichtbach and the Inde River, along with sections of the Hasselbach River and the Fischbach before they join the Vichtbach. The survey areas and the rivers are shown in Figure 6 to Figure 9.

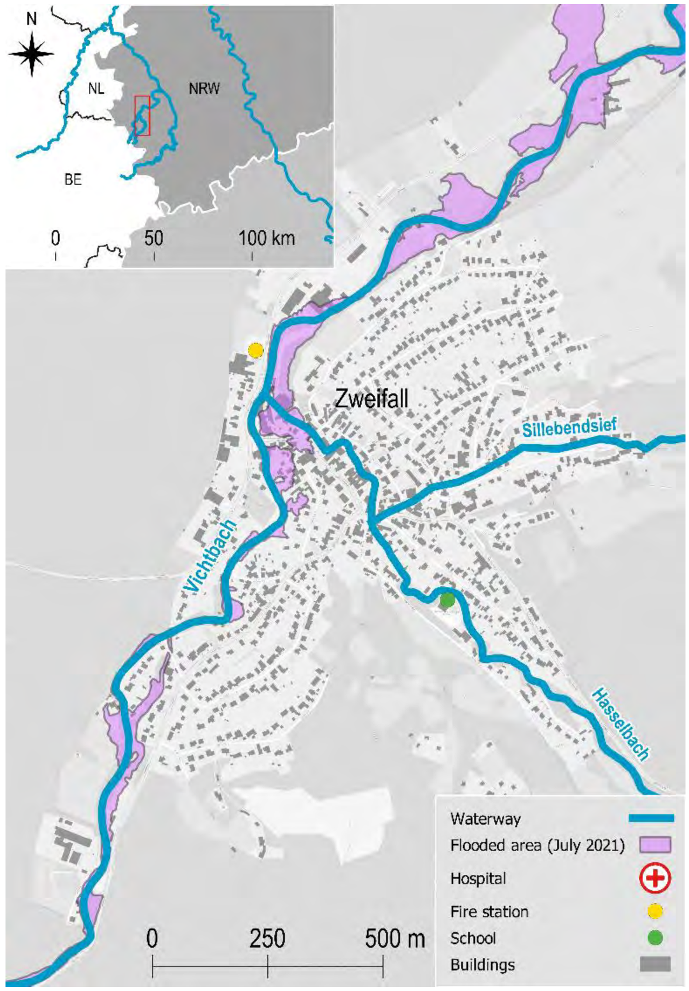



*Figure 6: Village of Zweifall, survey area Germany.*


*Figure 7: Village of Vicht, survey area Germany.*

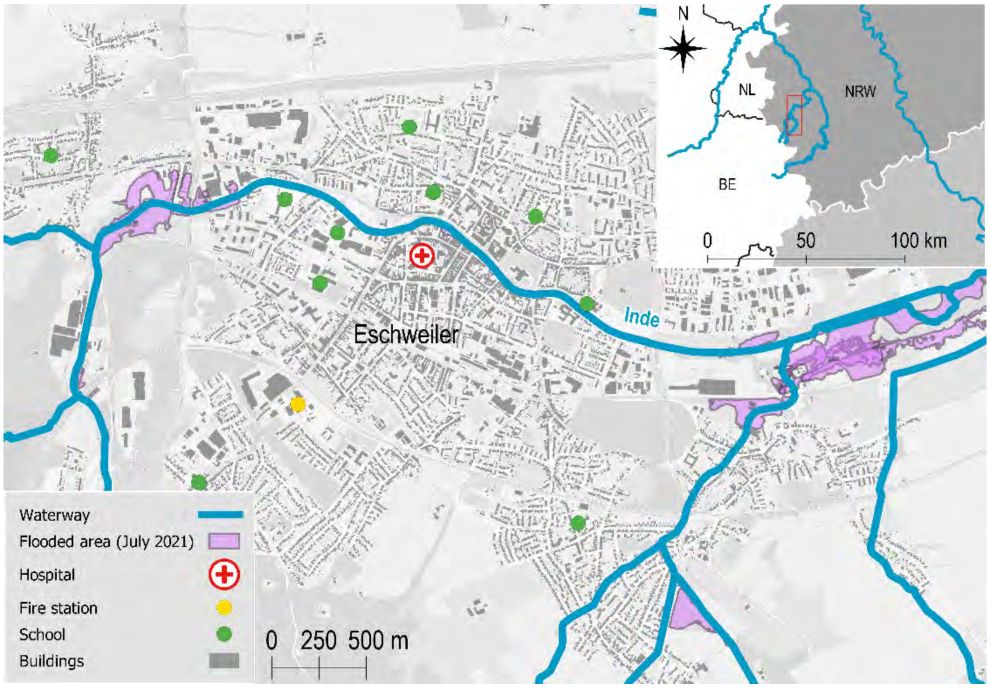



*Figure 8: City of Eschweiler, survey area Germany.*

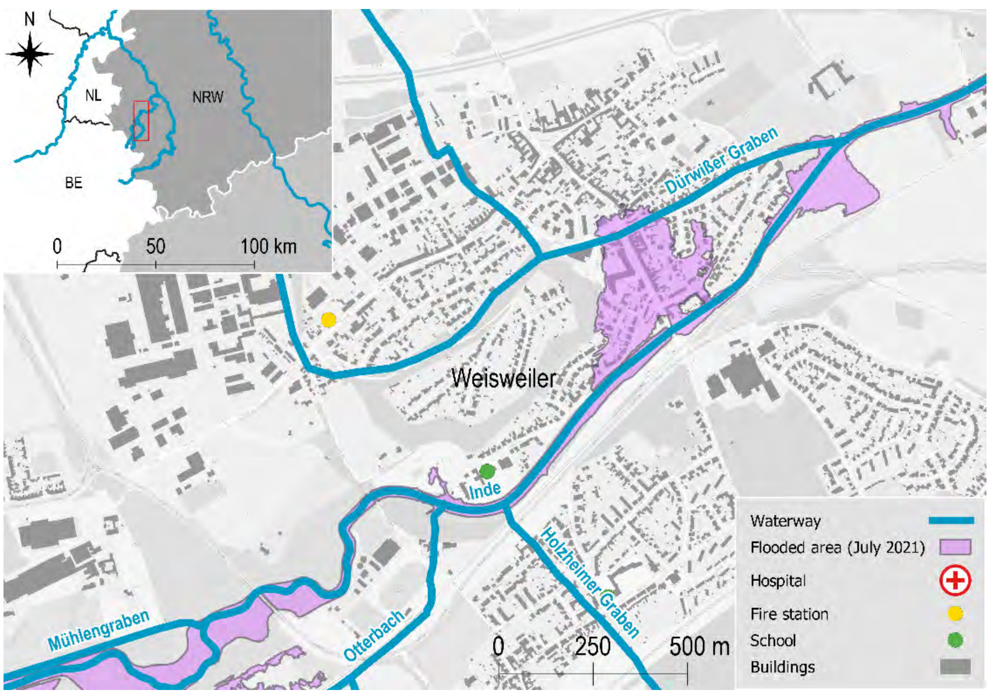



*Figure 9 : City of Weisweiler, survey area Germany.*

The Vichtbach, the second largest tributary of the Inde River, originates in Roetgen at an elevation of 416 meters above mean sea level. The river is a coarse material-rich low mountain stream (LAWA watercourse type 5) and is classified as a heavily modified water body (HMWB) in the city of Stolberg (MULNV NRW 2021). In the Vichtbach basin lies the Dreilägerbach Dam, which stores the water of the Dreilägerbach, a tributary of the Vichtbach and is used for drinking water supply which influences the Vichtbach (IT.NRW; KÖNGETER ET AL. 2013; WVER; WVER). The impoundment volume is 3.6 million m³. Vicht River has a catchment area of 104 km² and flows for 23 km before joining the Inde River at an elevation of 167 meters above sea level in Stolberg. Its basin constitutes about 30% of the basin of the Inde River.

The Inde River itself originates in Belgium at an elevation of 395 meters above sea level. The river's catchment area covers 344 km² in Belgium and Germany and features a mix of croplands, grasslands, forests, and urban areas. After entering Germany, the Inde River merges with the Rur River in Jülich, North Rhine-Westphalia, after a total length of 47 km. In addition to the Dreilägerbach dam's discharge into the Vicht River, the Inde River's flow is influenced by the Wehebachtalsperre, which serves both drinking water supply and flood protection purposes (MULNV NRW 2021; IT.NRW).

### 2.1.3 The Netherlands

In July, heavy rainfall caused significant flooding in large parts of Limburg. The water levels reached record heights, resulting in floods and damages to numerous cities and villages. Unlike most urban areas in the Netherlands, many cities and villages in the southern region of Limburg have a flood safety standard of 1:25 years, indicating a lower level of protection. The topography plays a crucial role in determining these lower flood safety levels in the south of Limburg compared to the rest of the country. The steep nature of the landscape limits the storage capacity in the upstream area, making it challenging to achieve higher levels of protection that remain cost-effective. The flood safety level of 1:25 years means that these areas must be safeguarded against high-water events with a return period of 25 years. However, under extreme conditions such as the high-water event in July 2021, parts of the city can still become inundated.

The municipality of Valkenburg was particularly hard-hit by the flood event in July 2021. The flooding in Valkenburg was primarily caused by fluvial flooding from the river Geul.

Located approximately 10 kilometres upstream from the Meuse, Valkenburg is located in the downstream section of the 58-kilometer-long river Geul. The river Geul is relatively small and flows through the historical centre of Valkenburg, resulting in significant damage in case of flooding.

The steepness of the area is also evident, with Valkenburg situated in the lower part of the valley.

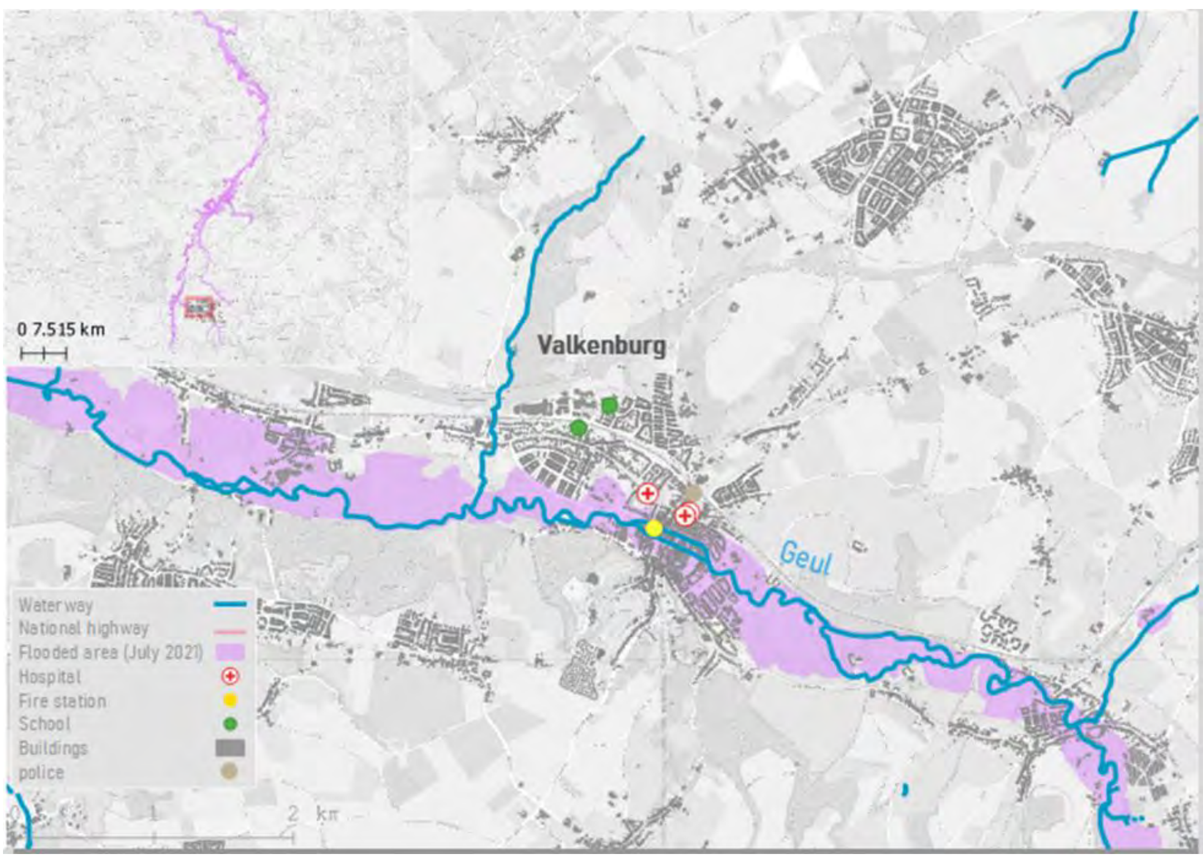



*Figure 10 : Elevation map Valkenburg with affected buildings*

## 2.2 Flood event in July 2021

### 2.2.1 Meteorology

In July 2021, a storm front named "Bernd" was present over Europe, starting to shift from southwest Europe towards Germany on July 12, 2021 (Junghänel et al. 2021).This storm front brought warm and moist air from the Mediterranean region due to its rotation (Junghänel et al. 2021). As a result, it caused a significant amount of rainfall in the river basins of the Meuse and Rhine rivers in Germany and the Benelux states starting from July 13, 2021 (CEDIM 2021; enw 2021).

Before noon on July 13, 2021, a large area experienced intense precipitation, which then moved north-eastward, northward, and from northern Germany to North Rhine-Westphalia (NRW) and Rhineland-Palatinate (RP) in western Germany (CEDIM 2021). During the night between July 13, 2021, and July 14, 2021, a zone with heavy rainfalls, thunderstorms, and floods extended across Germany, particularly above NRW (CEDIM 2021). The heavy and continuous rainfall, occasionally intensified by rain showers, persisted throughout July 14, 2021, and lasted until the early morning of July 15, 2021 (Junghänel et al. 2021).

Satellite images in Figure 11 illustrate the expansion and impact of the storm front. They show a vast and coherent cloud system located over Europe, with the cloud cover starting to dissipate from July 16, 2021, onward. By July 17, 2021, the area of western Germany and the Benelux states was free of clouds. These meteorological events, characterized by the movement and intensification of the storm front, resulted in a significant amount of rainfall across the region, contributing to the subsequent flooding.

During this flood event, an exceptionally large area experienced more than 100 mm of rainfall within a few hours or days, with some locations receiving over 150 mm (Junghänel et al. 2021; CEDIM 2021; MOHR ET AL. 2023). In the Geul catchment area, around 128 mm of precipitation fell over two days, July 13 and July 14 (VAN HEERINGEN ET AL. 2022). In Jalhay, Belgium, precipitation reached 271.5 mm in 48 hours (KMI). These amounts were 1.5-2 times (Junghänel et al. 2021) or 2 times (CEDIM 2021) the average precipitation for the entire month of July from 1991 to 2020 (Junghänel et al. 2021). The maximum hourly precipitation intensity recorded was 33 mm (CEDIM 2021). Many measurement stations in western Germany set new rainfall records, even though the available measurement time series span approximately 70 years (CEDIM 2021).

At the Cologne-Stammheim station, a new record of 165.1 mm of rainfall was measured, making it the wettest station of the German Weather Service (DWD) during the rain events between July 13, 2021, and July 15, 2021 (CEDIM 2021). Most of the rainfall events in Germany during this period were classified as events with a return period of at least 100 years, and in many areas, the rainfall exceeded this return period locally (CEDIM 2021; Junghänel et al. 2021). Based on a combination of measurements from past events and model simulations, it was estimated that the probability of such rainfall in the Meuse River basin is in the range of 1:100 to 1:1000 (enw 2021).

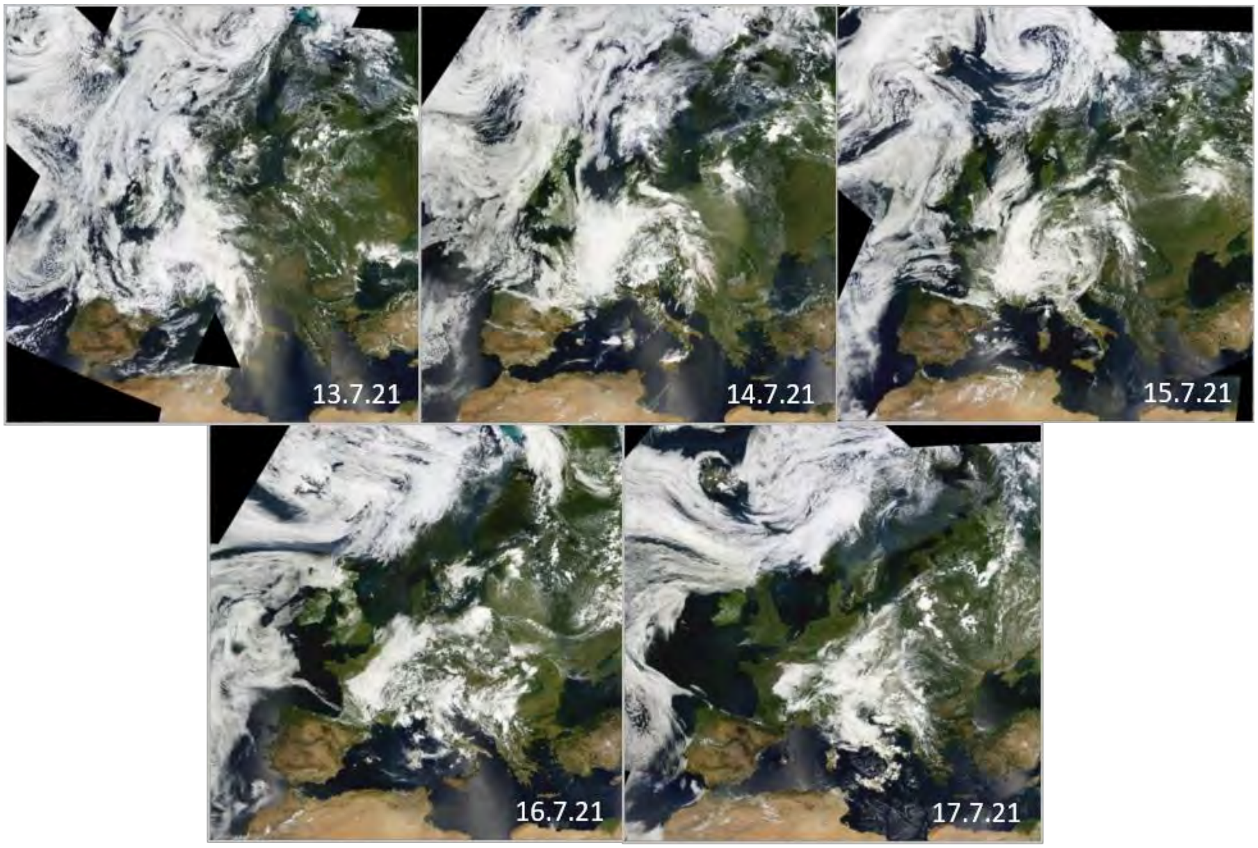



*Figure 11: Satellite images of Europe from the 13.7.21-17.7.21 (Deutsches Zentrum für Luft- und Raumfahrt (DLR)).*

### 2.2.2 Hydrology

The precipitation during the flood event was characterized by very high intensity, which persisted for an extended period over a large area. This prolonged and intense rainfall contributed to the adverse conditions in the river basins. In the affected German areas, the river basins are characterized by partially deeply incised river valleys, such as the Eifel and Ahr valleys, where the runoff is rapid and the water becomes highly canalized (Junghänel et al. 2021; CEDIM 2021). Moreover, significant portions of the river basins were already saturated with water due to a series of heavy rainfalls since May and recurrent precipitation events in the three weeks leading up to the events between July 13, 2021, and July 16, 2021 (CEDIM 2021; Junghänel et al. 2021; Bezirksregierung Köln 2021).

Because of the conditions described above, small rivers initially overflowed their banks (Junghänel et al. 2021). Sustained rainfall intensified on July 14th and 15th, 2021 (CEDIM 2021) leading to the overflow of medium-sized and large rivers as well. This resulted in extreme fluvial floods across Germany, Belgium, the Netherlands, and Luxembourg (CEDIM 2021; enw 2021). Initially, the dams in the affected regions were able to retain a portion of the precipitation. However, due to the river basins' inflow greatly exceeding the outflow, some dams eventually overflowed (Junghänel et al. 2021).

The most severely affected rivers included the Rur, Urft, Olef, Vichtbach, Inde, Wurm, Ahr, Kyll, Erft, Geul, and Gelenbeek (Bezirksregierung Köln 2021; CEDIM 2021; enw 2021). Numerous locations experienced record-breaking water levels, such as the Altenahr Gauge, which recorded an all-time high of 5.05 m and 332 m³/s (previous record: 3.71 m and 236 m³/s) (CEDIM 2021). However, this measurement does not even capture the highest water level and discharge at that location, as the gauge subsequently failed (CEDIM 2021), as did many others during that night. Estimates suggest that the maximum water level at the Altenahr Gauge reached approximately 6-7 m, with a maximum discharge of 400-700 m³/s (CEDIM 2021). Similar records were set along the Meuse River at Eijsden and its adjacent tributaries (enw 2021).

In the Southeast part of Belgium, the maximum cumulated precipitation volumes over 24h between July 13 and July 16 reached almost 200 mm at some locations. This value corresponds roughly to twice the monthly precipitations. Return periods estimated by the Belgian meteorological institute exceed by far 200 years in the upper part of the Vesdre catchment. Precipitation volume cumulated over 48 h were slightly below 300 mm, and they were record-high not only in the Vesdre catchment, but also further south-west in the Amblève and Ourthe catchments.

Along river Vesdre, which was most affected, all four existing gauging stations were either washed away by the flood, or failed for another reason (e.g., loss of power supply). Nonetheless, the partially available time series suggest also a very extreme flood wave. This is also confirmed by on-going hydrological assessment of the event which suggests that the currently estimated 100-year flood may have been exceed by a factor three at some locations along this river. Similarly to the situation on the Meuse river, flow gradients were also exceptional compared to what was already measured on this river. These elements certainly led to surprise effects at various levels(Dewals et al., 2021).

Unfortunately, the discharge measurement locations at the Geul did not function during the flood event. However, model calculations indicate that the peak discharge of the Geul in Valkenburg reached approximately 135 m³/s, while the average flow is around 4 m3/s. All gauging stations along the Vesdre river were also either washed away or disrupted for other reason (such as power supply failure), making flood monitoring difficult. Water depths measured in the town centre of Valkenburg reached approximately 1.25 meters.

The probability of such a fluvial flood event is estimated to range from 1:100 to 1:1000 for the Meuse discharge and between 1:100 and 1:1000 at various locations along the Geul, Gelenbeek, and Rur rivers (enw 2021). The return period of the July 2021 event for the Geul is estimated to be between 1:500 and 1:900 years. Parts of the Urft, Olef, Vichtbach, and Inde rivers clearly exceeded the HQextrem values indicated in the current flood hazard maps (SCHÜTTRUMPF 2021; Bezirksregierung Köln 2021). Hence in multiple places, the flooding extended beyond the official flood hazard zones, such as in the municipality of Verviers.

### 2.2.3 Evacuations

Approximately 50,000 people residing along the rivers had been evacuated in total (enw 2021). In the Netherlands, the majority of evacuations were self-initiated, aligning with the evacuation message conveyed by national and regional water authorities. However, the military also assisted in evacuating some individuals (enw 2021). Along the Meuse River, most people were successfully evacuated prior to the peak discharge (enw 2021). Unfortunately, in Valkenburg, located along the Geul River, a significant number of people were not evacuated before the flood reached the area (enw 2021).

In Belgium, approximately 2,000 individuals were evacuated in Liege (Junghänel et al. 2021). Additionally, rail traffic was disrupted in the provinces of Namur and Liege (Junghänel et al. 2021).

In Germany, several villages in the municipality of Euskirchen had to be evacuated due to the imminent risk of the Steinbach dam bursting (Junghänel et al. 2021). Furthermore, hospitals in Eschweiler, Ahrweiler, Leverkusen, Erftstadt-Liblar, and Trier-Ehrang also required evacuation (CEDIM 2021).

### 2.2.4 Damages

The magnitude of the floods resulted in severe damages and losses in the affected areas. The hilly terrain in Germany and Belgium intensified the catastrophic nature of the damages and losses (enw 2021). Several villages situated in the narrow valleys along the Vesdre, Ahr, and Sauer rivers were partially destroyed (enw 2021). These countries, where fatalities were recorded, experienced the greatest extent of damages and losses (enw 2021). The floods claimed the lives of over 200 individuals, with the majority of deaths (110) occurring in the Ahr valley (CEDIM 2021; Junghänel et al. 2021), at least 27 fatalities in Belgium (Junghänel et al. 2021), and hundreds of people injured (CEDIM 2021). Fortunately, there were no reported fatalities in the Netherlands (enw 2021).

In addition to the physical damages, the floods also led to an increase in patients with psychological complaints such as stress, anxiety, as well as cases of gastroenteritis, respiratory issues, and skin infections in the Netherlands (enw 2021). Psychological symptoms were cited as the primary reason for work absences in the country (enw 2021). Furthermore, the surge in Covid-19 infections in the province of Limburg suggests that the floods contributed to the spread of the virus (enw 2021). However, during and after the floods, measures to save lives took precedence over Covid-19 restrictions (enw 2021).

In the Netherlands, incidents of flood defence failures, such as sand-boils, embankment overflow, and breaches (at non-primary defences), have been reported along the Meuse River in certain locations (enw 2021). The flood also caused the disruption of the armour layer in the bed of the Grensmaas, resulting in multiple erosion pits with depths of at least 3 meters, riverbank erosion, sand deposition on the banks, and the transportation of significant amounts of debris (enw 2021). Around 2,300 houses were damaged, with 700 houses suffering severe damage. The historic centre, which is home to numerous shops, bars, and restaurants, was also heavily affected. Approximately 270 catering facilities and 180 shops experienced the impact of the flood (NOS Nieuws 2021) and by preliminary estimations more than 5,000 residents have been affected (enw 2021). These entities have incurred damages to their properties, business interruptions, infrastructure damage, and crop losses (enw 2021). The most substantial damages in the Netherlands were observed in the Geul floodplain (enw 2021).

In the southern part of Belgium, the flood event resulted in significant devastation, particularly affecting residential, commercial, and infrastructure sectors. Approximately 100,000 people were reported as being impacted, and around 45,000 private and social buildings suffered damage. The infrastructure also took a substantial hit, with 559 bridges affected, and damage observed in various networks. Notably, 66,500 electrical connections, 47,000 water distribution connections, 12,700 communication lines, and 15,150 gas connections were reported as affected. Rail traffic was disrupted in the provinces of Namur and Liège. Leisure areas experienced repercussions as well, with 160 sports facilities and 594 agricultural parcels sustaining notable damages. The commercial sector bore a considerable brunt, with over 3,000 commercial buildings affected, some of which remained inactive even a year after the flood event. The overall estimated cost of the damages exceeded EUR 3 billion (CSR, 2022).

In Germany, the damage due to the flood in July 2021 was one of the most significant since 1945 (WVER 2021). Residential buildings and infrastructure suffered devastating damages (CEDIM 2021). In the Ahr valley, numerous buildings were completely destroyed (Bezirksregierung Köln 2021). The infrastructure also sustained significant damage, with all rail bridges destroyed, roads and railway tracks washed away, and disruptions to electricity, drinking water supply, and communication systems (Junghänel et al. 2021). Access to the Ahr valley was completely cut off due to impassable roads (CEDIM 2021).

According to Bezirksregierung Köln (2021), there were instances of breaches in flood protection dams. In the flooded areas, numerous buildings suffered damage, including flooded basements, ground floors, and in some cases, upper floors (CEDIM 2021). The affected areas were strewn with debris and vegetation. The infrastructure sustained significant damage, leading to restrictions in railway and road traffic (CEDIM 2021). Additionally, the drinking water and electricity supply systems were disrupted, and telephone and mobile networks were overloaded and partially non-functional due to electricity and cable outages (CEDIM 2021).

The total economic damages resulting from this event are significant. The event's total economic damage for Europe is estimated at 49 billion Euros (Munich Re 2022). In Germany, it is reported to be higher than 30 billion Euros (WVER 2021) and up to 33 billion Euros (Munich Re 2022), making it the most expensive natural disaster ever recorded in Germany (Munich Re 2022). However, only 37-47% of the damaged buildings were covered by elementary insurance, which provides coverage for flood damages (CEDIM 2021). In the Netherlands, the total economic damage is estimated to be in the range of 350-600 million Euros (enw 2021). The observed damage to residential and commercial structures varies significantly (enw 2021).

In addition to the aforementioned countries, other European countries such as Luxembourg, France, Switzerland, and Poland were also affected by the consequences of the mid-July 2021 storm front (Junghänel et al. 2021).

## 2.3 Previous studies

In the aftermath of the 2021 flood, several studies were undertaken in the three countries.

### 2.3.1 Belgium

A masterplan for the Vesdre catchment was elaborated by Studio Paola Viganò and the Team Vesdre- of ULiège. It builds upon a comprehensive analysis of many aspects of the 2021 flood event (hydro-meteorological causes, flow processes, and an overview of the flood impacts) and aims at elaborating a vision and guidelines for resilient urban planning throughout the Vesdre catchment, including guidance on reconstruction in the affected areas. We focus here on the damage analysis part.

Various types of damages are detailed in the study, based on existing datasets and visual surveys. The study highlights that the floods have increased inequalities in the population. Many of the people who lived in the Vesdre valley and were affected by the floods are less affluent than the average of the population in the region. This is consistent with previous findings suggesting that more socio-economically vulnerable people tend to be overrepresented in flood-hazard areas, while the hillsides and plateaus, less exposed to floods, are generally inhabited by a more privileged population (Poussard et al., 2021).

Beyond the monetary losses in the residential sector that the present project contributes to capture, floods also lead to psycho-social consequences. Some people lost relatives, sentimentally valuable objects, and insurance procedures have been a burden for a substantial fraction of the victims, making recovery challenging. Although not directly quantified here, such effects have been observed during the EMfloodResilience interviews, either through some of the responses to the questionnaires, or even in the refusal of some people to take part in the survey due to for instance traumatism.

According to the study by Studio Paola Viganò and the Team Vesdre of ULiège, the Vesdre valley is among the most vulnerable valleys in the Walloon Region regarding flood risks for residential buildings. This results from the valley configuration (relatively narrow, with steep hillslopes) and the numerous buildings concentrated within and close to the flood hazard zones. The study also highlights that, following the 2021 flood, around 265 buildings were destroyed or needed to be demolished due to the extent of damage.

The commercial buildings (shops and businesses) also suffered from direct and indirect damages. The study underlines that the most economically vulnerable shops were the most impacted ones because it has been harder for them to recover. In May 2022, there were still 297 inactive shops due to the floods. Regarding the businesses, most of them were active again in May 2022.

Regarding public buildings and infrastructures, Verviers was the most damaged municipality. In many municipalities of the Vesdre valley, the extent of damages faced by buildings normally involved in crisis management (such as fire stations or police stations) has led to rethink the positioning of some of these structures and their structural resistance. The study also highlights that touristic buildings were impacted since some of the equipment was situated next to the river and that patrimonial buildings of the Vesdre valley were impacted by the floods too.

While the study by Studio Paola Viganò and the Team Vesdre of ULiège present an overview of damages in various sectors, restricted to the Vesdre valley, the present deliverable of the EMfloodResilience project provides a more in-depth analysis of damages in the residential sector across several municipalities in Belgium, Germany and the Netherlands.

### 2.3.2 Germany

As part of the project "HoWas 2021: Governance and Communication in the Event of the July 2021 Flood Crisis," a group of scientists from the Institute of Environmental Science and Geography at the University of Potsdam conducted surveys in all regions affected by the floods in July 2021. The survey took place between August 25th and October 17th, 2021, and was conducted exclusively online using SoSci Survey, an online questionnaire tool. It was promoted through Facebook, a press release to local newspapers, and information provided to the mayors (THIEKEN ET AL. 2023). A total of 892 respondents from NRW and 423 from RP completed the survey (THIEKEN ET AL. 2023). The survey captured socio-demographic characteristics such as gender, age, and household size of the participants (THIEKEN ET AL. 2023). The questionnaire consisted of 22 questions, mainly focusing on the warning system during the July 2021 flood in Germany (THIEKEN ET AL. 2023).

The results were published for all the collected data (THIEKEN ET AL. 2023) as well as separately for each district, including the district of Aachen (also known as Städteregion Aachen) (HEIDENREICH 2023).

In the district of Aachen, the following results are presented. A total of 121 participants, with an average age of 42.6 years, took part in the study (HEIDENREICH 2023). Among them, 47.4% live in the municipality of Stolberg, 31.5% in the municipality of Eschweiler, and 12.6% in the city of Aachen (HEIDENREICH 2023). The gender distribution shows that 56.7% of participants are female, 37.8% are male, and 5.5% did not disclose their gender (HEIDENREICH 2023).

Regarding flood experience, 85% of the participants stated that they had never been affected by a flood before, 9.4% had experienced a flood once before, and only one person had experienced multiple floods (HEIDENREICH 2023).

When rating the magnitude of the flood situation at their residence, 55.1% of participants ranked it as "very strong" (6), 23.6% as "strong" (5), and only 21.3% ranked it within the four lower categories, where category 1 means "not affected at all" (HEIDENREICH 2023). However, the perceived magnitude of the flood situation within their own household varied significantly. Only 23.6% of participants rated it as "very strong," while 11.0% rated it as "strong" (HEIDENREICH 2023).

The questionnaire also inquired about the highest water level experienced within the participants' houses. In the district of Aachen, 11.8% of the participants reported no water in their houses, while 15.7% had water in their basements (HEIDENREICH 2023). Among those who had water on the ground floor and/or upper floors, 7.9% encountered water levels up to 0.5 m, 15.0% experienced water levels between 0.5 m and 1.0 m, 27.6% had water levels between 1.0 m and 2.0 m, 10.2% faced water levels between 2.0 m and 4.0 m, and 2.4% dealt with water levels exceeding 4.0 m (HEIDENREICH 2023). The average water level of the participants in the district of Aachen was higher than the overall average water level for all participants in NRW (HEIDENREICH 2023).

When participants were asked about the cause of the flooding in their houses, the most commonly selected response was "flood due to overflowing watercourse" (referring to a nearby river or smaller body of water overflowing its banks), which was chosen by 78.0% of the participants in the district of Aachen (HEIDENREICH 2023). 40.9% selected 'the sewage system could no longer drain the water on the road', 32.3% selected 'water running wild on the surface of roads or slopes', 22.8% selected 'rising groundwater', 14.2% selected 'The water entered directly via drains, toilets, showers from the sewage system into the rooms below street level (e.g. basement rooms)', 8.7% selected 'floods as a result of a dyke breach or dam failure' and 9.4% of the participants were not flooded at all (HEIDENREICH 2023).

Regarding the warning of flood danger, 20.5% of the participants from the district of Aachen did not receive any warning, which is significantly lower than the overall percentage in NRW, which stands at 36.8% (HEIDENREICH 2023). Among those who did receive a warning (multiple answers were possible), the majority (29.9%) received warnings from other individuals such as neighbours, colleagues, friends, through phone calls, emails, WhatsApp messages, or direct conversations (HEIDENREICH 2023). An additional 28.3% received warnings through social networks such as Facebook or Twitter (HEIDENREICH 2023). Furthermore, 25.2% received warnings through weather forecast apps, 24.4% through their own internet research, and 22.8% through weather warning apps like Katwarn or NINA (HEIDENREICH 2023). Warning sources that reached less than 20% of the participants from the district of Aachen were television (15.7%), radio (12.6%), authorities or disaster control sites such as the fire brigade (12.6%), sirens or loudspeakers (6.3%), daily newspapers (3.9%), personal observations (3.1%), and evacuation call warnings (3.1%) (HEIDENREICH 2023). Apart from the smaller percentage of people who did not receive a warning, the most notable difference compared to the warning sources in NRW is the significantly higher percentage of people in the district of Aachen who received warnings through social media (28.3%) compared to the overall percentage in NRW (11.7%) (HEIDENREICH 2023). Other distributions in the district of Aachen are similar to those in NRW.

The questionnaire also inquired about the significance and coverage of different warning topics. According to Figure 12, which illustrates the results of this questionnaire, all of the mentioned topics were deemed important by the participants, scoring at least 4.7 on a scale from 1 to 6. However, as depicted in Figure 12, most of the topics reached fewer than one-third of the participants in the flood warnings of July 2021. The largest disparities between the importance of a topic and its inclusion in the July 2021 flood warnings were observed for the topics 'expected water level,' 'information about dam or dike breaches,' and 'assessment of the threat to life in the situation.' The most highly valued topic among the participants was information about endangered areas, receiving a score of 5.9 out of 6. Conversely, the topic of information regarding diversions, road closures, train cancellations, etc., was considered the least important by the participants in the district of Aachen, with a rating of 4.7 out of 6.

Another noteworthy result of the survey indicates that 88% of the respondents were completely caught off guard by the event (HEIDENREICH 2023)

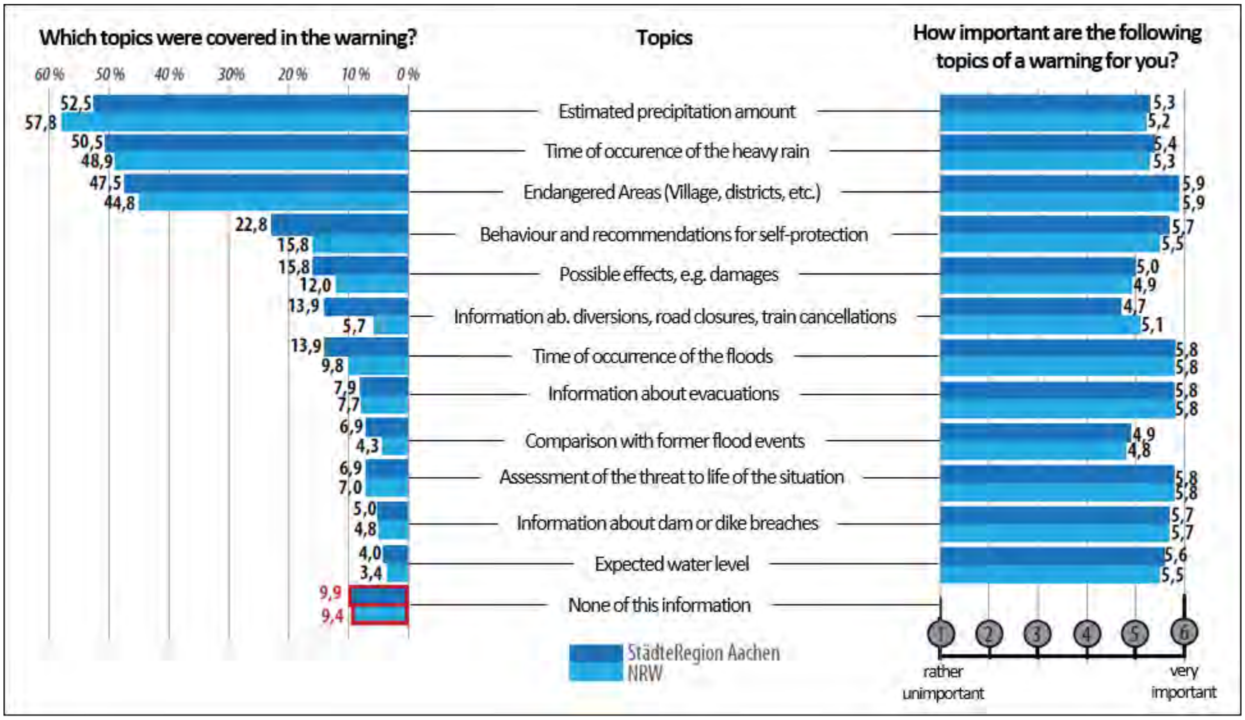



*Figure 12: Appearance and importance of different topics in the warning, modified after HEIDENREICH (2023).*

The participants were also asked about the precautionary measures they had taken. In the district of Aachen, 58.3% of the respondents reported taking mitigating actions upon becoming aware of the potential flood risk, such as securing important documents or elevating furniture (HEIDENREICH 2023). Nearly an equal percentage of individuals (52.8%) stated that they had provided information or assistance to others (HEIDENREICH 2023). Other measures taken included 'Searching for information about heavy rains/floods' (35.4%), 'seeking refuge in a safe location' (26.8%), 'turning off electricity and gas' (16.5%), 'preparing for evacuation and packing essential documents/items' (13.4%), and 'seeking help' (11.0%) (HEIDENREICH 2023). Only 8.7% of the respondents continued with their daily routines without considering the flood event (HEIDENREICH 2023).

### 2.3.3 The Netherlands

As part of the project "Experience From the 2021 Floods in the Netherlands: Household Survey Results on Impacts and Responses", researchers from TU Delft in cooperation with researchers from VU Amsterdam and Utrecht University conducted descriptive surveys with the companies Deltares in Delft and HKV Consultants in Lelystad in the regions affected by the floods in July 2021 (ENDENDIJK ET AL. 2023). In total, 1,513 household surveys were conducted online in the southern part of the Netherlands (in the province of Limburg) (ENDENDIJK ET AL. 2023). The household surveys captured measures of evacuation, mitigation and compensation, as well as other characteristics such as risk perception and stress (ENDENDIJK ET AL. 2023). In particular, the impact on the population in the areas of flood damage and evacuation, a comparison was made between the population group that was aware of an increased flood risk and had previously derived appropriate measures and the population group that was not aware of this (ENDENDIJK ET AL. 2023). Thus, this study provides insights into the Dutch disaster management.

The following results were presented for the province of Limburg. Floods mainly entered at the surface; only 20% of the respondents mentioned groundwater or sewers as a source (ENDENDIJK ET AL. 2023). Flood heights varied from a few centimetres to more than two metres of water depth (ENDENDIJK ET AL. 2023). The flood depths were significantly higher on the Geul than on the Meuse; in some cases the water even reached the second floor of the residents' houses (ENDENDIJK ET AL. 2023). On average, 76% of the people who received an evacuation notice actually evacuated (ENDENDIJK ET AL. 2023). In general, little official help was needed for evacuation. Moving property to higher ground in the house resulted in almost 50% less damage (ENDENDIJK ET AL. 2023). Placing sandbags or flood protection walls was generally ineffective due to the high water levels (ENDENDIJK ET AL. 2023). The greatest damage was observed along the Geul and near the confluence of the Roer and Maas rivers (ENDENDIJK ET AL. 2023). Similar to the situation in NRW, private insurance was not applicable for a large part of the affected population in the NL (> 40%) and therefore they were not compensated (ENDENDIJK ET AL. 2023).

# 3 Material and Methods

## 3.1 Questionnaires

New questionnaires have been developed by drawing upon existing questionnaires used for the collection of flood damage data in various countries, including Italy, Germany, and the Netherlands. To comply with data privacy regulations, the questionnaire has been divided into two sections. The first part holds the personal information and focuses on the socio-economic characteristics of the residents, such as educational attainment and socio-professional category, as well as the location of the buildings. The second part, created separately for residential and commercial buildings, holds the research data and asks about information pertaining to the various dimensions of risk (hazard, exposure, and vulnerability). The aim is to identify commonalities, differences, strengths, and weaknesses across the three countries, thereby contributing to a broader understanding of flood risk management and offering recommendations for improvement.

The questionnaire aims to facilitate comprehensive data collection on the flow characteristics observed during the July 2021 flood event. It seeks information on various attributes to describe the hazard, including maximum water depth, perception of flow velocity, flood duration, and the presence of sediments, contaminants, and debris. Additionally, the questionnaire considers the features of buildings within the flooded area that may increase the community's susceptibility to the flood impact. These features encompass building type (such as attached, detached houses, or apartment blocks), building structure, year of construction, number of floors, ground water height, and the presence of a basement. In the field survey, the response capacity of the population is also collected, recognizing the importance of flood experience, preparedness, and early warning systems in mitigating monetary losses. The questionnaire also invites respondents to provide their insights on measures that could contribute to the concept of "Building Back Better."

The post-flood scenario needs the establishment of budget allocation and compensation frameworks. Additionally, the quantification and comparison of potential risk reduction options are crucial for determining the most effective cost-benefit measures. These requirements underscore the importance of acquiring flood damage data. Therefore, the flood survey includes a dedicated section for retrieving flood losses in the surveyed buildings. This section seeks information from the population regarding the types of damage incurred by buildings and their contents, along with associated costs. Furthermore, respondents are asked to provide details on any compensation received or the utilization of public or private funds to mitigate the impacts of the flood.

Consequently, the field survey has been designed to contribute to a comprehensive transboundary database encompassing all aspects of flood risk. Its primary objective is to estimate the direct impacts of flooding on residential buildings, thus enabling further analysis and fostering an enhanced understanding of the flood risk in the region.

## 3.2 Survey strategy

The survey aimed to gather information on the direct losses of residential buildings, which were among the most affected sectors in the three regions during the July 2021 flood event. The target areas were chosen with consideration for other research initiatives that commenced after the flood event to prevent overlap. To ensure an adequate number of surveys could be conducted, not only was a questionnaire developed for the residential sector, but also for the commercial sector—a sector that was highly impacted during and after the floods. This approach was taken in case the residential sector alone did not provide a sufficient basis for the targeted number of surveys.

For conducting the surveys, different strategies were evaluated, including online, phone, and field survey interviews. Ultimately, paper-based field surveys were chosen, despite their higher cost, due to the potential for obtaining higher-quality data and the ability to make supplementary notes when additional information was shared by the residents, which may not have been explicitly addressed in the questionnaire. However, it is important to note that this selected approach introduces a bias, as accessing demolished and abandoned houses proved challenging even more than one year after the flood event.

Hence, the interviews were preferably conducted in person, directly with the affected individuals or via telephone, if a personal interview was not possible for individuals. To achieve this, a decision was made to visit each house within the affected area and kindly request people's participation in the survey. Considering the restrictions for the regulations outlined in the EU General Data Protection Regulation (GDPR), which are applicable to all survey areas, the necessary restrictions were taken. Both parts of the questionnaire are identified and linked by a unique code, ensuring the use of anonymous data. Every participant provided their consent by signing a form regarding the usage of their data that explains the purpose of collecting flood damage information and ensures the confidential use of the data before the interview. Only if the resident signs the consent form is their information recorded and stored in the project's database. All partner universities (TU Delft, RWTH, and Uliège) have signed a responsibility agreement, guaranteeing the secure handling of the data.

### 3.2.1 Belgium

To encourage participation in the field survey, the University of Liège employed a communication strategy based on delivering letters directly to households a few weeks prior to the start of the interviews. These letters provided a summary of the study's objectives and motivation, along with different options for conducting the survey: scheduling an appointment, contacting the resident via SMS, email, or an online form accessible through a QR code provided in the letter, or waiting for the university researcher to arrive at the house. If the resident scheduled an appointment or agreed to be interviewed upon the researcher's arrival, a comprehensive predefined questionnaire was administered. The Belgian interviews were conducted from February 2023 to May 2023, which for safety purposes were conducted in teams of two people.

The field surveys were planned in the selected areas based on the point wise water depth map of the water authorities in the Walloon region (SPW) conducted shortly after the flood event, currently available in their geoportal (https://geoportail.wallonie.be). The surveys were planned to start from the buildings with high to low water levels reported in the map, with the intention to collect information on the damage costs due to the flood event.

Although the field interviews took place over a year and a half later, there were instances where certain cases had to be abandoned due to relocations or ongoing house repairs. In these situations, residents who had left their phone numbers in the front door for emergency contact were reached out to for survey participation. Additional phone call surveys were conducted in the case where the inhabitants were unavailable during the on-site visit or scheduling a future appointment was challenging.

Statistics on the participation rate and reasons for unwillingness to participate (i.e., No advantage to answer, not available, traumatized by the event) were recorded from individuals who answered the door during the on-site visits.

### 3.2.2 Germany

RWTH Aachen University designed a poster to announce the upcoming surveys, which were printed and displayed as posters (DIN A3) and flyers (DIN A5) in various shops and bakeries within the survey areas of Stolberg and Eschweiler. The poster includes a description of the EMfloodResilience project and the survey, as well as a photo of the survey team consisting of a research associate and two student assistants. Contact information is also provided. Additionally, the survey was promoted on the homepage of the Institute of Hydraulic Engineering and Water Resources Management, as well as on the corresponding Facebook page. The German interviews started in March 2023 and ended in July 2023. On the second day of the survey, a reporter from the local newspaper accompanied some interviews with the consent of the participants. An article about the surveys was subsequently published on Saturday, April 8, 2023.

For safety purposes, the interview teams always consisted of two individuals. If the front door was not opened, a flyer similar to inform the inhabitants was left in the mailbox. The flyer contains information about the project, the fact that the survey team attempted to contact the residents and contact details. When residents did open their front door, the survey team introduced themselves and explained that they were conducting surveys about the flood as part of an international scientific project. They then asked if the residents would like to participate. Depending on the response, the interview team either conducted the interview inside the participant's home, scheduled an appointment for a later date and time, or proceeded to the next door.

In addition to visiting potential participants at their homes, the RWTH survey team attended a "talking brunch" on floods (German: Gesprächsbrunch Hochwasser) organized by the cities of Eschweiler and Stolberg, as well as several aid organizations. This brunch, which began in March 2023, provided an opportunity for people affected by the flood to gather, share experiences, and receive assistance from the aid organizations. The RWTH survey team attended the brunch multiple times, engaging with the flood-affected individuals, and scheduling interview appointments with them.

The following statistics were recorded regarding participant generation:

- The number of doors that were open to the survey team and the number that were not.

- The number of people who agreed to participate in the interview after opening their door for the survey team.
- Reasons given by individuals who chose not to participate in the study.
- The number of participants interviewed with appointments from:
    - The talking brunch in Eschweiler.
    - The talking brunch in Stolberg.
    - Contact made through the posters.
    - Contact made by ringing at their door.

Additionally, records were maintained regarding the number of buildings left abandoned and those that were demolished due to flood damage.


*Figure 13 : Poster/flyer designed by RWTH Aachen and distributed in the survey area.*

### 3.2.3 The Netherlands

TU Delft arranged a meeting with the mayor of Valkenburg, Daan Prevoo, to discuss potential participation options and willingness. The mayor responded with enthusiasm, expressing a willingness to share resources for raising awareness about the upcoming surveys.

For safety purposes, the interview teams always consisted of two persons. In cases where there was no response at the door, a flyer containing project information and contact details was left in the mailbox.

When residents answered the door, the survey team introduced themselves and explained that they were conducting surveys as part of an international scientific project focused on floods. They then asked if the residents would like to participate. If residents expressed interest in participating, the interview was either conducted inside the house or an appointment was scheduled for a later date. In cases where residents declined participation, the team thanked them politely and proceeded to the next door. The Dutch interviews were conducted between July 2023 and September 2023. As the Dutch survey team registered, in the city of Valkenburg not only residents but also many businesses were affected the project team decided to design an additional questionnaire part 2 for businesses to get insight into the damages and damage impact factors in this sector as well.

During the interviews, all survey teams recorded the answers on a printed version of the survey. Using printed surveys added a personal touch to the interaction with homeowners, with one team member engaging in conversation while the second team member primarily took notes.

Throughout the survey process, the teams kept track of the following statistics regarding responses at the door:

- Number of people not at home.
- Number of people willing to participate.
- Locations where appointments in the future are made.
- Number of people not interested in participating.
    - Reasons for declining participation when given.

Additionally, any vacant buildings due to flood damage were also noted during the survey.

## 3.3 Encoding and data curation

All survey teams recorded the answers on a printed version of the survey. The printed surveys allowed for note-taking during the interview, which would not be possible when immediately filling in the answers on digital devices. After the field interview, the conducted questionnaires were stored using Kobotoolbox. A data collection, management, and visualization platform used globally for research and social purposes.

To ensure high-quality data, each conducted survey was encoded twice. Therefore, each survey has an identification number, which consists of a 10-digit timestamp, and two encoding numbers (-1 or 0) depending if it was the first or the second encoding of the survey as shown in Table 2.

*Table 2: Exemplary code assignment.*

| Survey code | Entry code |
|---|---|
| 1234567890 | -1 |
| 1234567890 | 0 |

Once the survey is encoded twice, ideally from a different surveyor, the next step involves the comparison and final correction if different answers are provided. For that, a an excel sheet with all the recorded answers is exported from Kobotoolbox and using a developed Python script (shown in Appendix B), the comparison and the correction of all the surveys is performed. As a result, a final excel sheet with just one entry per interview and survey code is created.

This sheet contains all data which was compared and corrected and henceforth contains the final data set. These represent the raw data for the data analysis.

## 3.4 Data analysis

The collected data is analysed with descriptive statistics. As, the questionnaires hold four different types of questions, which are listed in Table 3, for each type of questions one type of output was determined. Ther percentages of the answers of single choice questions are shown in a horizontal bar chart. For multiple choice questions it was decided to create vertical bar charts, showing the percentages of people who ticked the different answers. For questions that ask for a free number such as an amount of money, box plots were designed, which show the minimum, median and maximum value as well as the first and third quartile. For open questions like 'Which needs do you still have that have not yet been addressed', where participants could give free answers, the answers are listed in tables. For two questions in the questionnaire, which ask about a year (e.g., the year people were affected by a flood the last time before the event in July 2021) timelines were created. According to this, a graph was created for every question of the questionnaires for all countries. These are displayed in chapter 4.

*Table 3: Types of questions of the questionnaires and the form of output of their results.*

| Type of question | Output |
|---|---|
| Single choice | Horizontal bar-chart |
| Multiple choice | Vertical bar-chart |
| Free number | Boxplot |
| Free text | List (table) |
| Year | Timeline |

# 4 Results and Discussion

In the following the results of the survey statistics as well as the results of the questionnaires are presented and discussed. The results of the questionnaires are in the same order as the corresponding questions in the questionnaire.

## 4.1 Belgium

In the surveyed Belgian region, field surveys were conducted in the municipalities of Chaudfontaine, specifically in the Vaux district, and in the municipality of Theux. A total of 35 surveys were carried out in each of these areas.

### 4.1.1 Survey statistics

In Belgium, only houses where the researcher interacted with the inhabitants were registered in the dataset. As depicted in Figure 14, only 30% of the contacted individuals actively participated in the field survey. Among the remaining 70% who chose not to participate, various reasons were documented as shown in Figure 15. The primary hindrance to participation was unavailability, a limitation inherent in the survey plan, as the surveys were scheduled during weekdays and working hours. Additionally, 21% of individuals expressed disinterest, while an additional 18% mentioned a perceived lack of benefit as their reason for not participating.

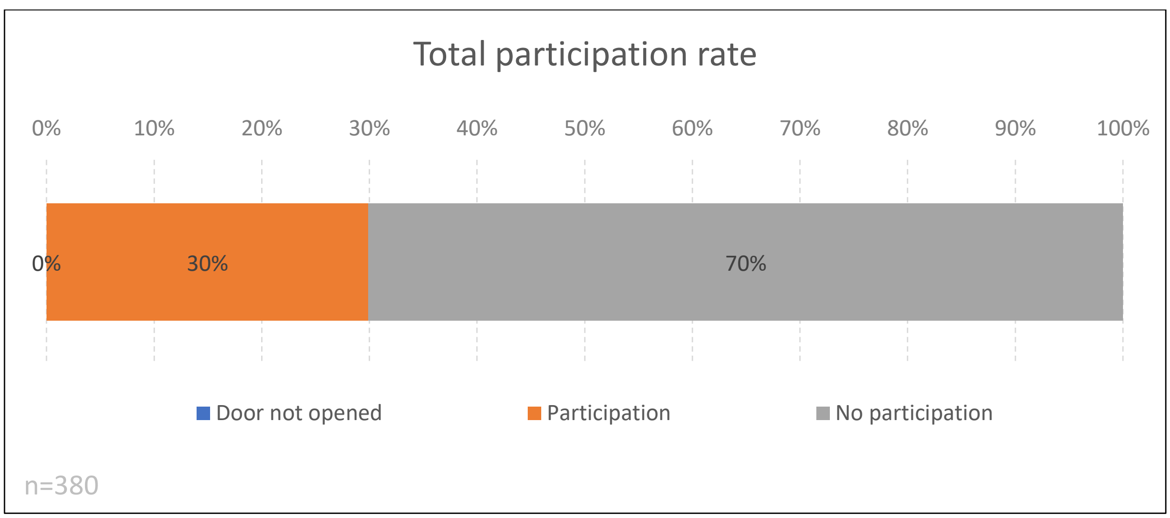



*Figure 14. Participation rate, Belgium*

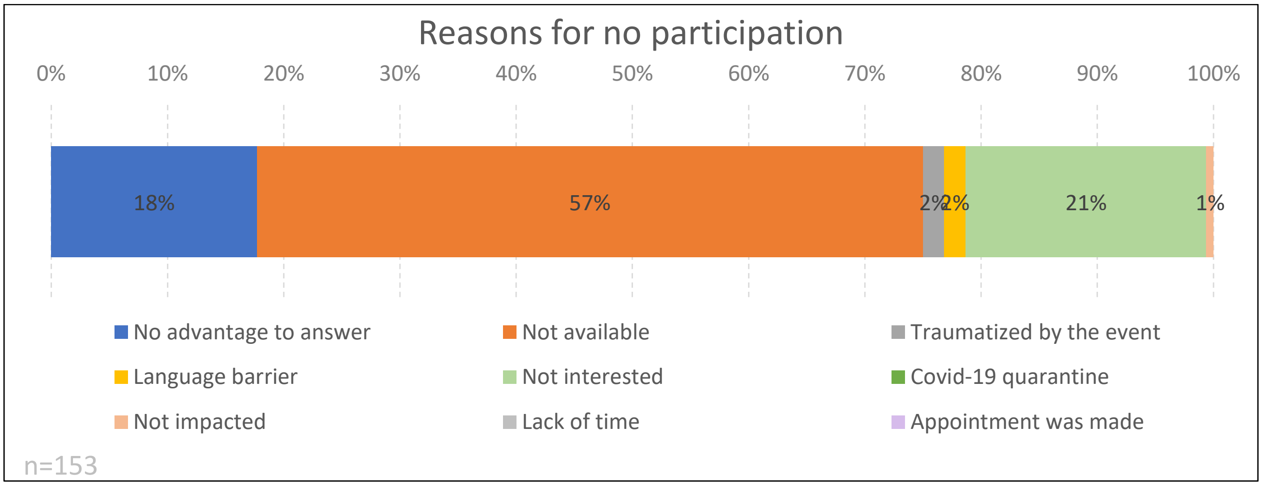



*Figure 15. Reasons for not participating, Belgium*

### 4.1.2 Part 1

The first section of the questionnaire contains data related to the socio-economic characteristics of the respondents. There is some bias in the sampled population since the field surveys were conducted on weekdays during working hours. Indeed, a significant portion of the respondents are retired individuals, comprising 64% of the sample (Figure 18). Moreover, approximately 65% of the surveyed population possesses a high school level of education or less (Figure 17)

A substantial amount of the interviewed participants (89%) are in the category of low to medium education levels, spanning from elementary school to bachelor's degree. This observation hints at the possibility of a higher share of individuals with a relatively lower socio-economic status living in flood-prone areas, as suggested by (Poussard et al. (2021).

As indicated in Figure 142 in Appendix, 91% of the respondents express a keen interest for being kept informed about the results of the study. This is a positive indicator as it provides an opportunity to raise awareness among the population about the hazards they are exposed to, ultimately contributing to a better-prepared community for future flood events.

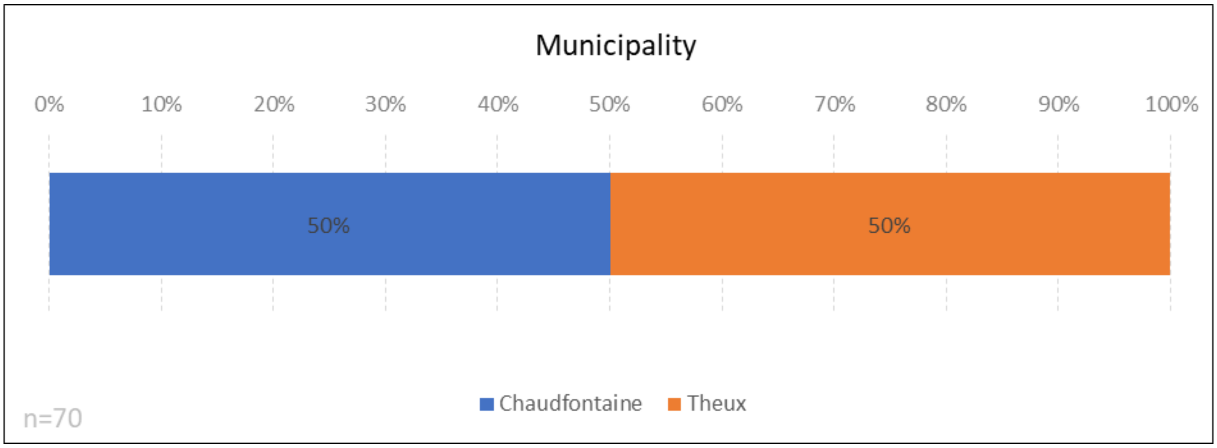



*Figure 16 : Percentages of municipalities the participants live in, Belgium (questionnaire part 1, question 2).*

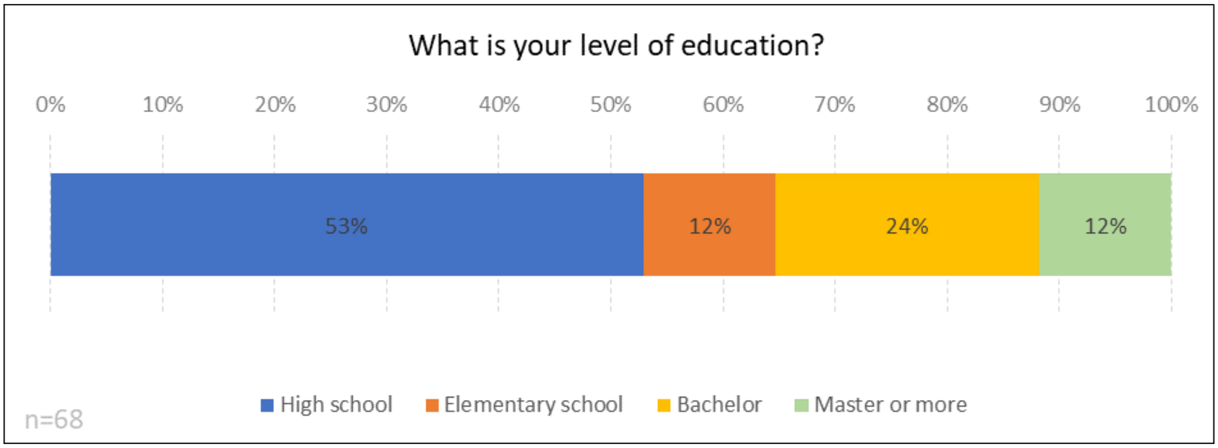



*Figure 17 : Percentage of the level of education of the participants, Belgium (questionnaire part 1, question 10).*

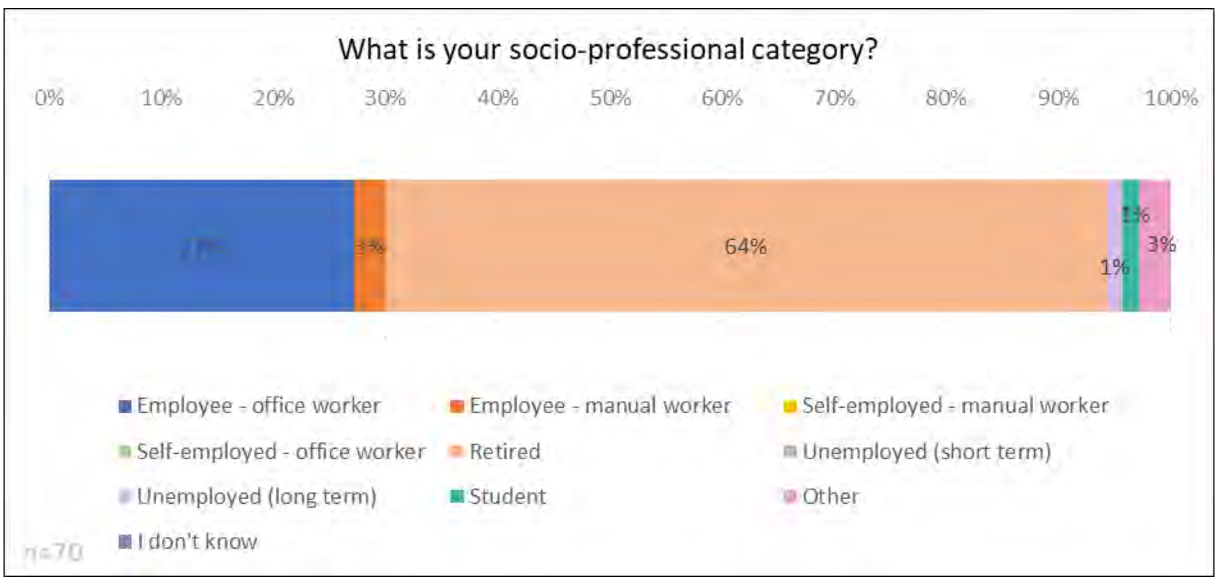



*Figure 18 : Percentages of the socio-professional categories of the participants, Belgium (questionnaire part 1, question 12).*

### 4.1.3 Part 2 (Residential sector)

Each questionnaire typically requires an average of 45 minutes to be completed, with some people extending their participation to around 120 minutes in cases where they were inclined to share additional information (Figure 143). In these cases, the people shared supplementary materials, including photographs, videos, and personal accounts of their experiences during the flood event.

Being aware of the difficulties that some people may have to participate in the survey within the allocated timeframe, phone interviews were considered as an alternative method to enhance community participation. Approximately 3% of the interviews were conducted over the phone rather than in person in the field (Figure 144). This approach was not encouraged due to certain limitations. Some of the information that researchers could verify, and measure on-site become less reliable in phone interviews, as these details were no longer directly observable.

## Hazard

In the Belgian studied area, in general, both the basement and the ground floor experienced flooding (Figure 19), with a median water depth of 1.7 m. The highest recorded water level outside the building reached 2.75m in the surveyed area (Figure 20). The flood event was characterized as a fluvial flood. This is in agreement with the perception by the population that the overflow of a watercourse was the main cause of the dwellings being flooded (Figure 21). In addition to high water depths, the flood was described as a fast flow, as indicated in Figure 22 and Figure 23, where 64% people defined the flood as torrential.

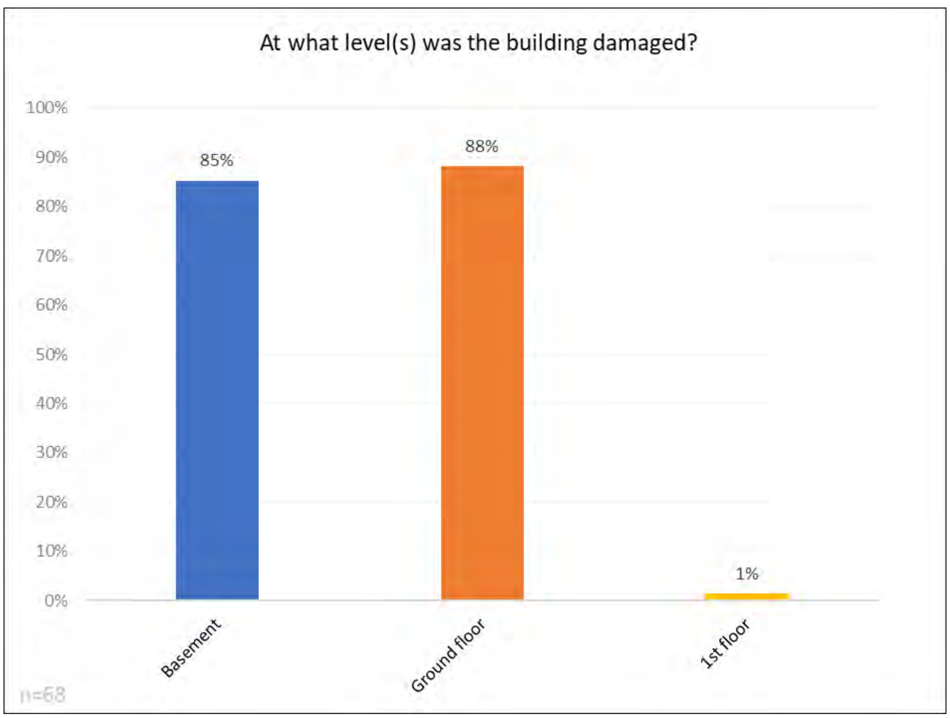



*Figure 19: Percentages of the levels, on which the homes of the participants are damaged, Belgium (questionnaire part 2 residential, question 9).*

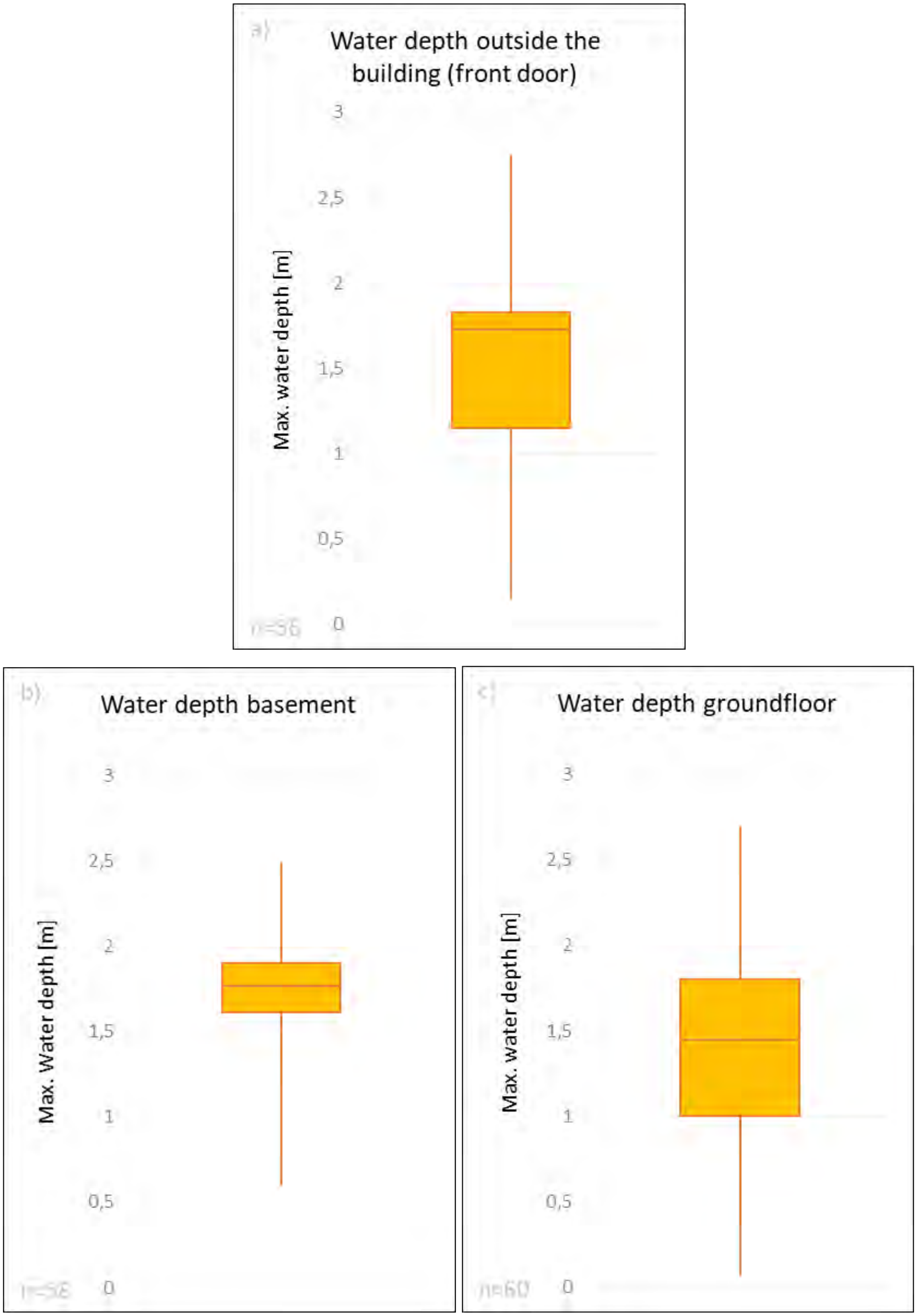



*Figure 20: Box plot of the maximum water depth during the flood a) outside the building (front door), b) in the basement and c) on the ground floor, Belgium (questionnaire part 2 residential, question 3).*

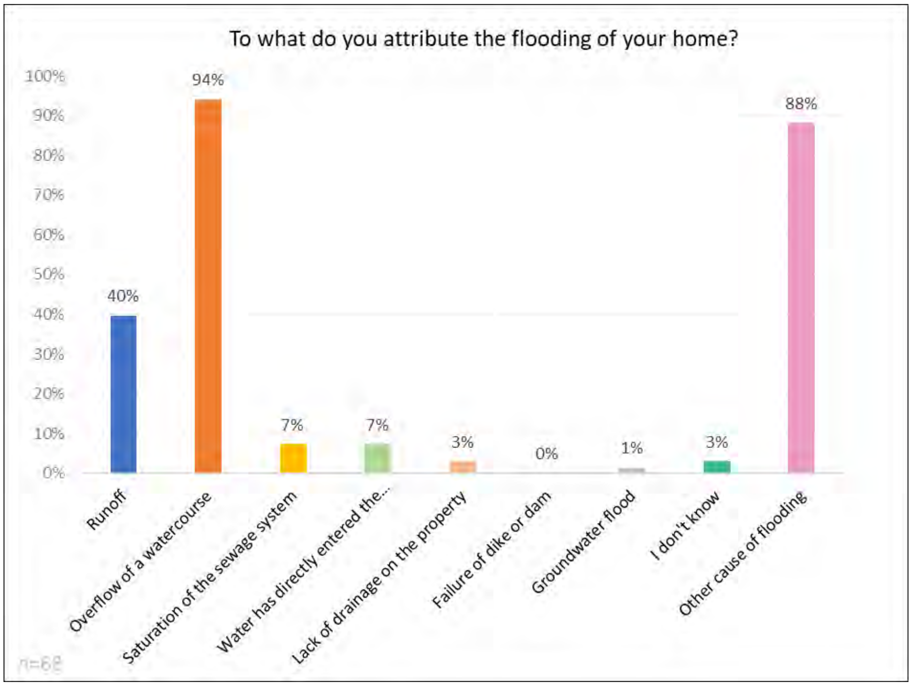



*Figure 21:Percentages of to what the participants attribute the flooding of their home to, Belgium (questionnaire part 2 residential, question 5).*

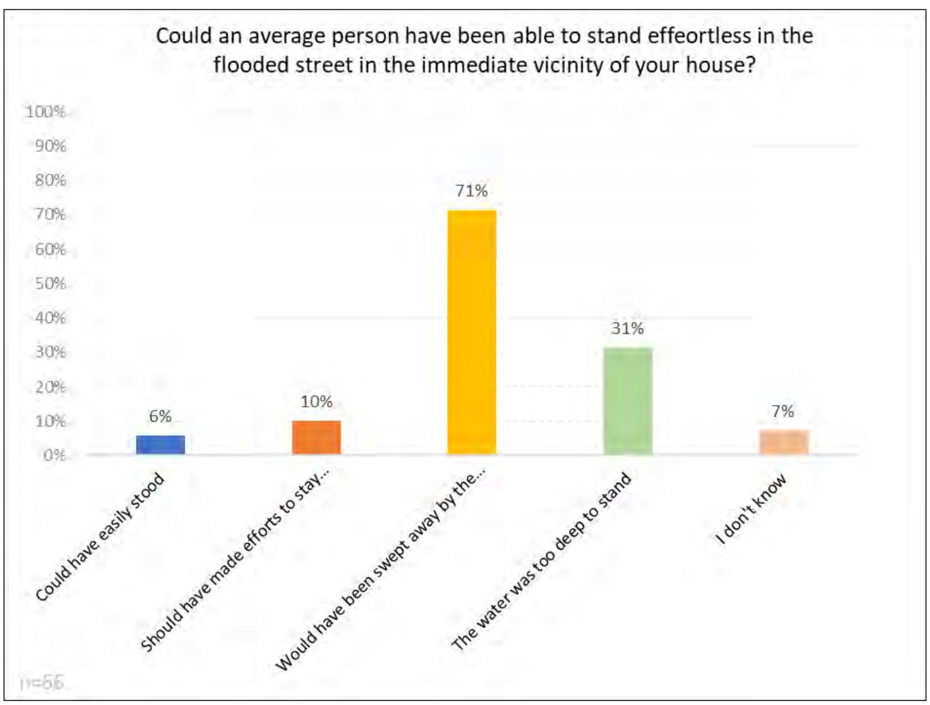



*Figure 22: Percentages of subjective estimates of the magnitude of the momentum/velocity by the participants, Belgium (questionnaire part 2 residential, question 7).*

In addition to the velocity, which allowed the transportation of large debris (between 2 and 3 m in length, as shown in Figure 24), the flood was also characterized for containing sediments and contaminants. Almost all the respondents reported to have encountered transported or deposited material from the floodwaters. Mud, sand, stones, vegetation, garbage, rubble, and large objects with a maximum size of 3 m, were the reported materials in the water. The presence of mud in 99% of the cases has induced a considerable work to clean and dispose the material out of the houses after the event (Figure 25).

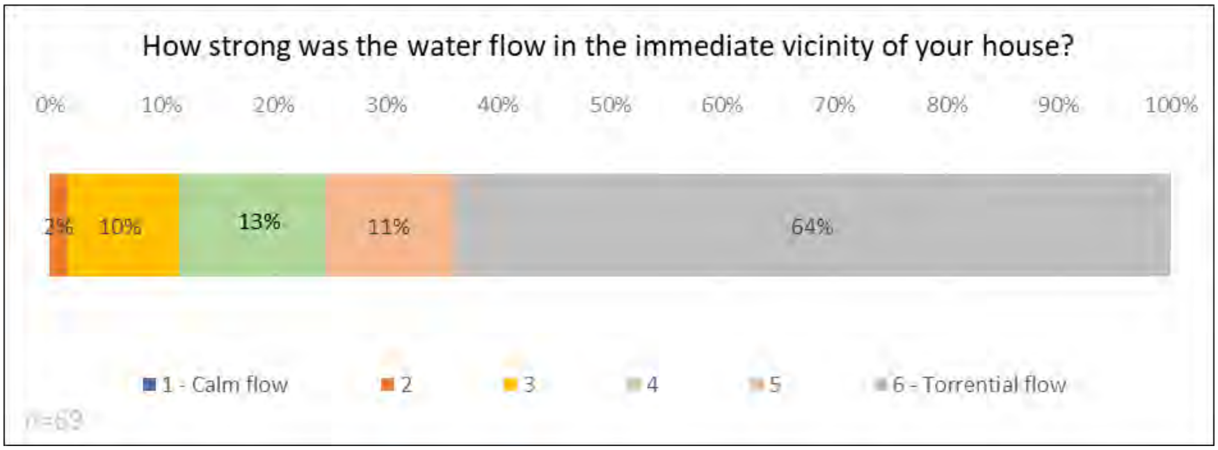



*Figure 23: Percentages of the estimation of the strength of the water flow in the direct vicinity of the participants homes, Belgium (questionnaire part 2 residential, question 13).*

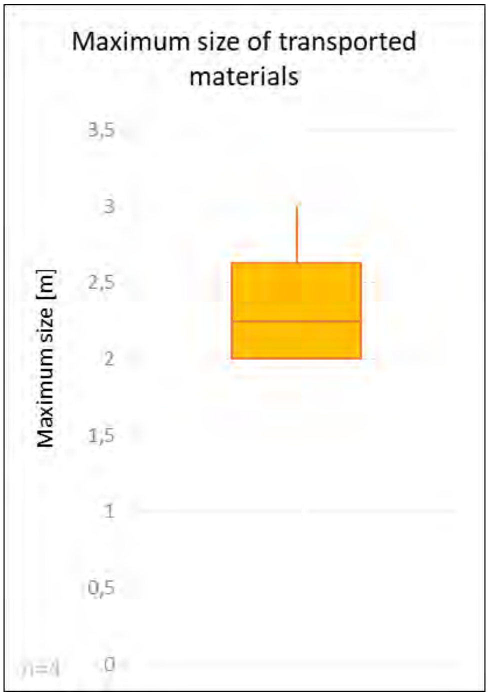



*Figure 24:Box plot of the maximum estimated size (length) of the transported/deposited materials in question 11, Belgium (questionnaire part 2 residential, question 12).*

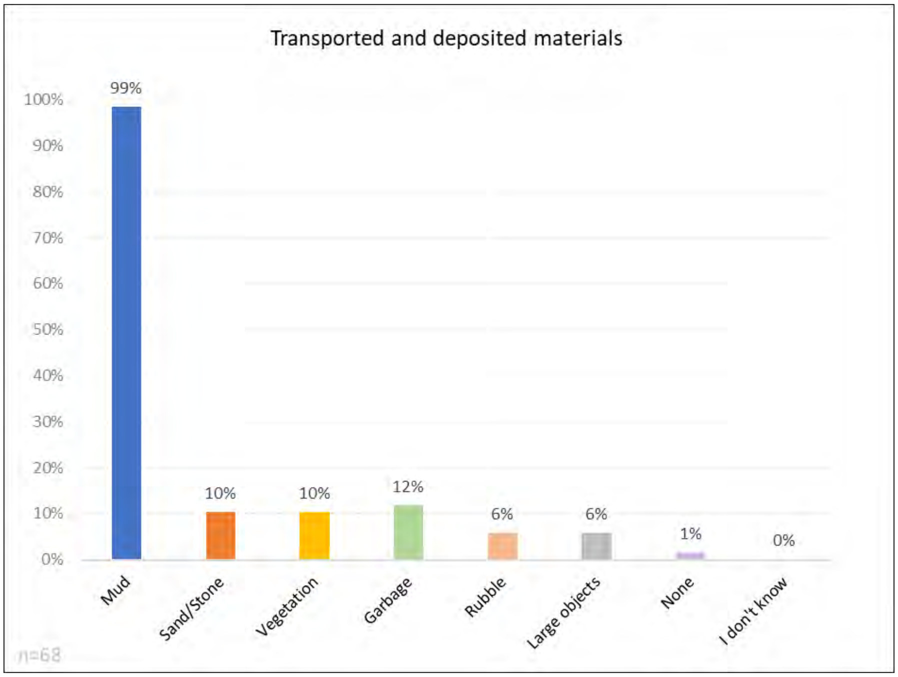



*Figure 25: Percentages of what materials were transported or deposited in the buildings or had direct contact with them, Belgium (questionnaire part 2 residential, question 11).*

In addition to the presence of sediments, contaminants such as chemicals, sewage water and hydrocarbons were also reported by the inhabitants. In Belgium, 44% of the buildings experienced presence of hydrocarbons, which add an additional cost of decontaminating the floors and walls in contact with the water (Figure 26).

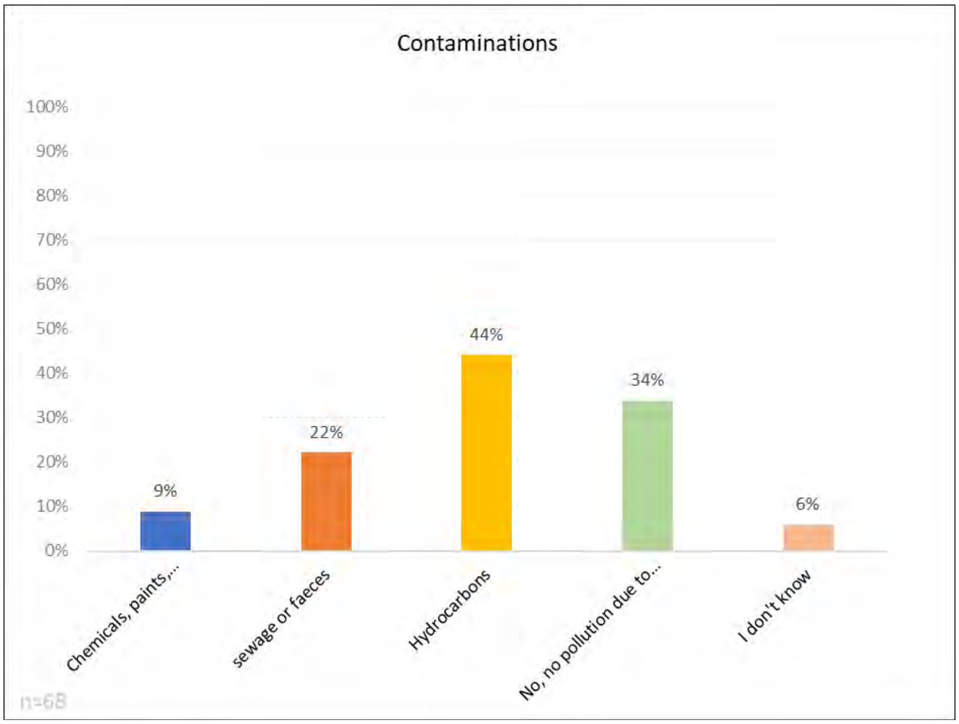



*Figure 26: Percentages of the records of the observed contaminants in the homes of the participants, Belgium (questionnaire part 2 residential, question 14).*

While conducting field surveys, it became evident that the presence of hydrocarbons within buildings is, in part, attributable to the common practice of housing heating systems in basements (29% as shown in Figure 27). In certain instances (12%, as indicated in Figure 156), these heating systems utilize oil. Adequate protection against floating of the oil tank may have been missing in some cases. Consequently, during a flood event, these systems are prone to oil leaks and spillage.

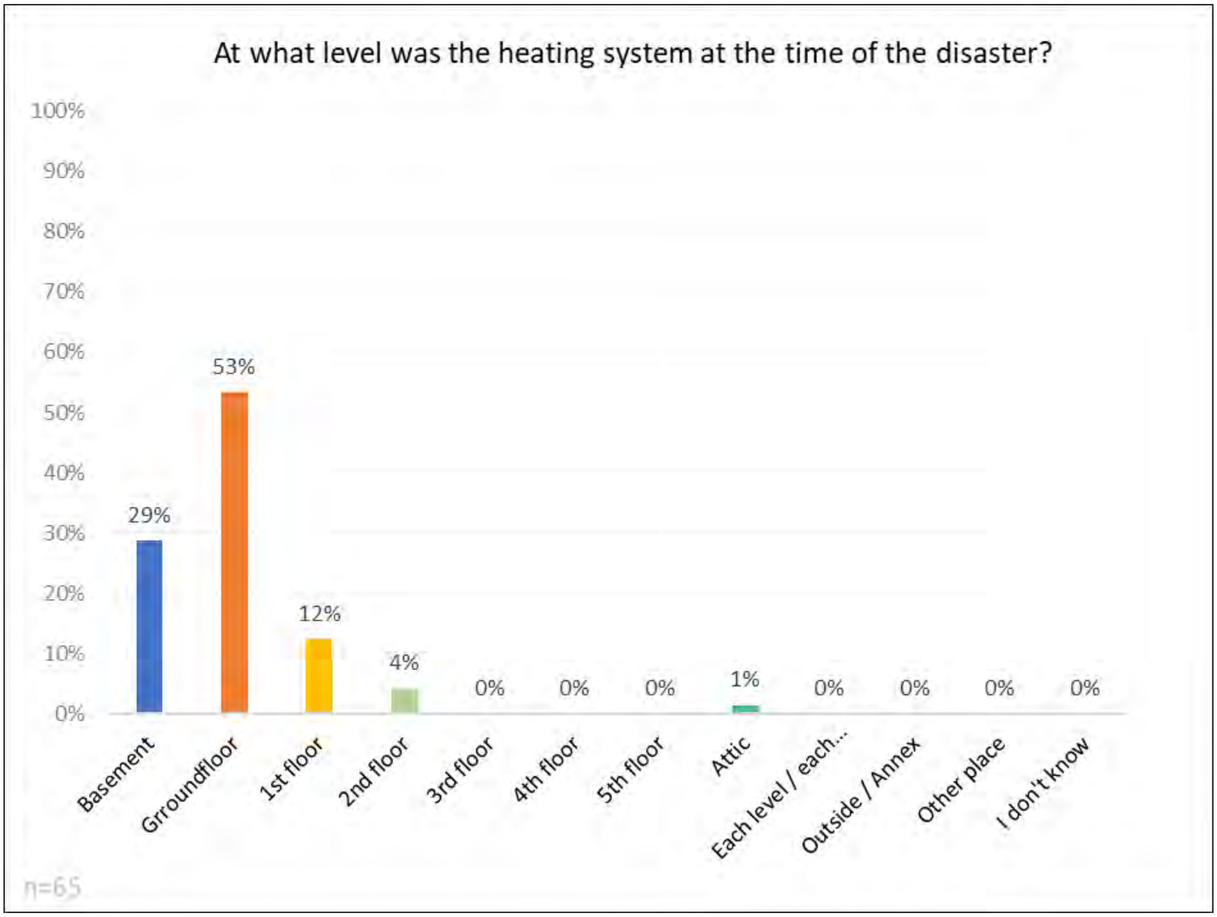



*Figure 27: Percentages of at which the heating system was located before the flood, Belgium (questionnaire part 2 residential, question 37).*

## Vulnerability

One of the aims of the second part of the survey is to characterize the exposed items (i.e., residential buildings) to appreciate their vulnerability to floods.

In the surveyed area in the Walloon region, it's common to find attached residential buildings, which account for 65% of the surveyed buildings (Figure 152). These are buildings that share their walls with other structures, resulting in a total of only two facades exposed to floodwater. They tend to be older buildings, with approximately 90% of them built prior to 1970, as indicated in Figure 28.A number of them had been renovated mostly in the time period between 2010 and 2020 (Figure 29). These buildings are typically constructed using clay bricks, as shown in Figure 154, and they generally feature four floors, including a basement, ground floor, first floor, and an attic. Despite their verticality, these buildings often have a relatively small footprint, measuring around 75 square meters (Figure 148).

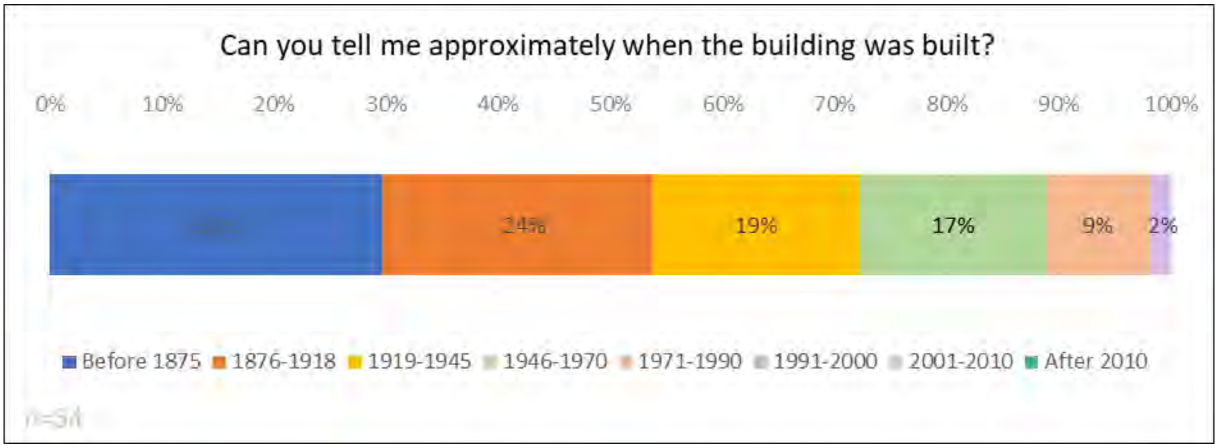



*Figure 28: Building period of the buildings the participants live in, Belgium (questionnaire part 2 residential, question 33).*

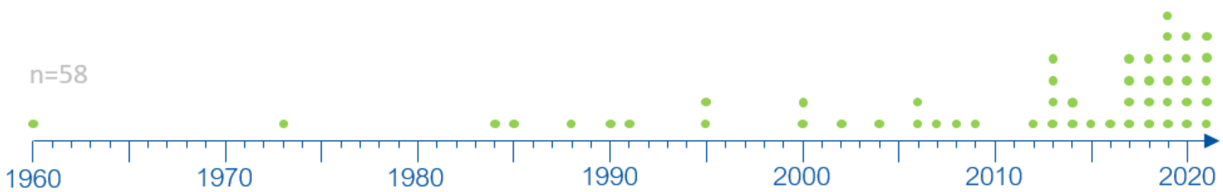



*Figure 29 : Last major renovations of the buildings the participants live in, Belgium (questionnaire part 2 residential, question 34).*

Another significant feature observed in the residential buildings within the surveyed area in Belgium is the inclusion of steps at the main entrance, providing access from the main street to the ground floor of the house. These steps typically elevate the ground floor to an average height of 0.3 meters (Figure 146). This elevation of the ground floor, which is often finished (as illustrated in Figure 147), serves to reduce its vulnerability to moderate flood events.

## Damage

The field survey has enabled collecting information on the damages to the buildings and their content. Regarding the building content, the affected population lost many types of appliances and household items as shown in Figure 149. Most of them are commonly located on the ground floor, which is generally finished and furnished as shown in Figure 147. Apart from important electrical appliances, the respondents experienced in 90% of the cases loss of memorabilia, which are intangible damages difficult to quantify and, in most cases, impossible to replace (Figure 149). The reported monetary losses for the household items, estimated at 85% by experts, has a median value around 23,000 euros for the surveyed buildings (Figure 30).

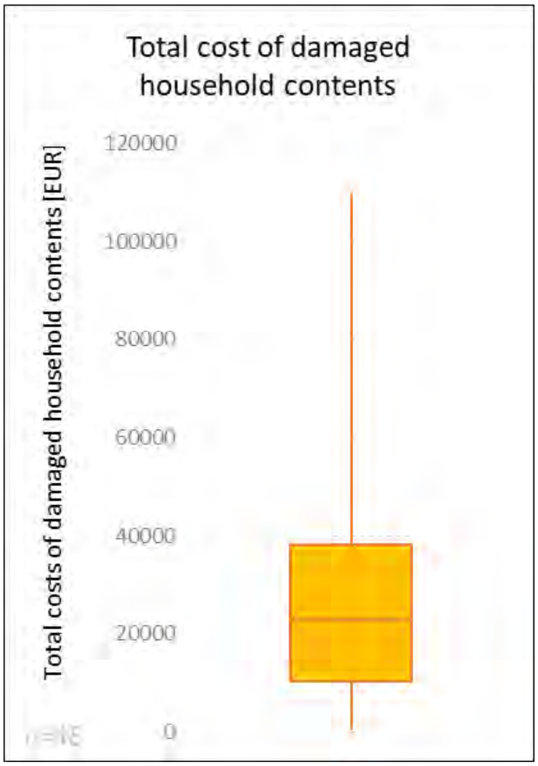



*Figure 30: Box plot of the total costs of damaged household contents of the participants, Belgium (questionnaire part 2 residential, question 19).*

Given that the basement was typically used as a storage area prior to the flood event, with an occurrence rate of 84% (as depicted in Figure 155), various valuable items such as wine, food, and personal collections were also lost. Additionally, the heating system control was situated in the basement in 29% of cases and on the ground floor in 53% of cases (as indicated in Figure 27).

The water level in most surveyed houses partially covered the ground floor level, which resulted in damage to the boiler and other heating components, as reported in Figure 149. In the Belgian context, damage to the heating system has been identified as a significant contributor to the overall building damage, accounting for approximately 15% of the total. This damage comes at a median cost of 8,050 euros (Figure

157), representing 71% of the overall damage to the building systems (Figure 158), which also considers damage to the electrical and plumbing systems.

Participants to the survey were asked to classify the state of their household items on a scale from '1-fully functional' to '6-household items still have significant defects of shortcomings'. Figure 31 shows, that 47% of the respondents (n = 38) had their households fully functional again at the time of the interview (conducted during the first quarter of 2023). Only 5% of them still had significant defects or shortcomings.

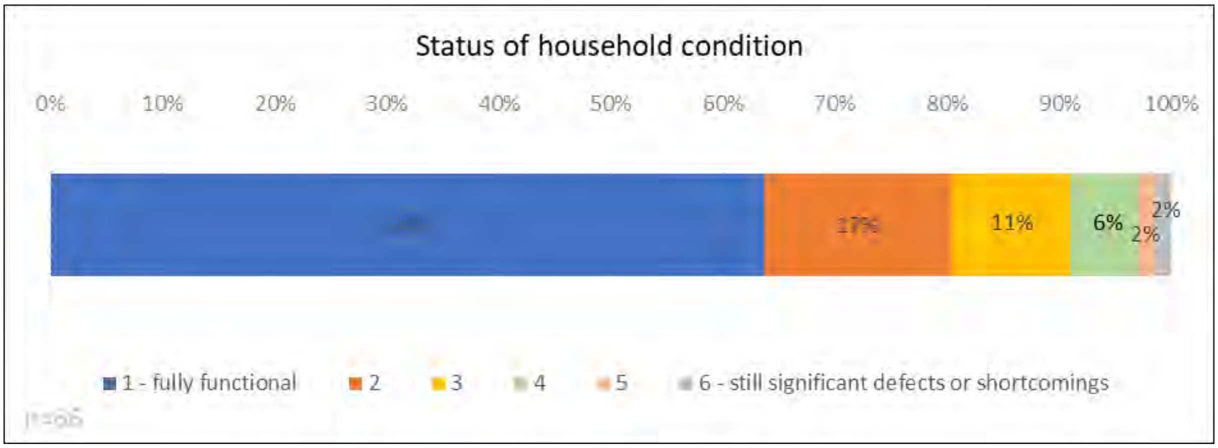



*Figure 31: Percentages of people who ranked the status of their household's condition in the different categories, Belgium (questionnaire part 2 residential, question 24).*

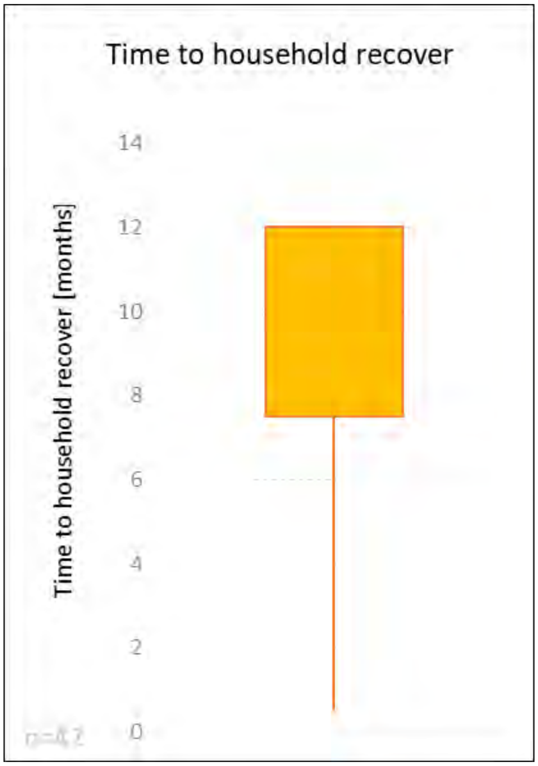



*Figure 32: Box plot of the number of months the household of the participants needed to fully recover, Belgium; median, third quartile and maximum = 12 (questionnaire part 2 residential, question 25).*

In addition to the reported damage of the building content, the damage to the building itself was also characterized. Damage to the pavement, interior lining, doors, windows and in some cases structural damage such as cracks (21% of the cases see Figure 33) were the most frequent damages described by the respondents. It is important to highlight that apart from the initial direct damages described by the inhabitants, some of them which, at the time of the field survey, had completed the reparation of the building also described secondary effects that appeared after the reparation such as humidity, fungus, and the smell of contaminants in the house.

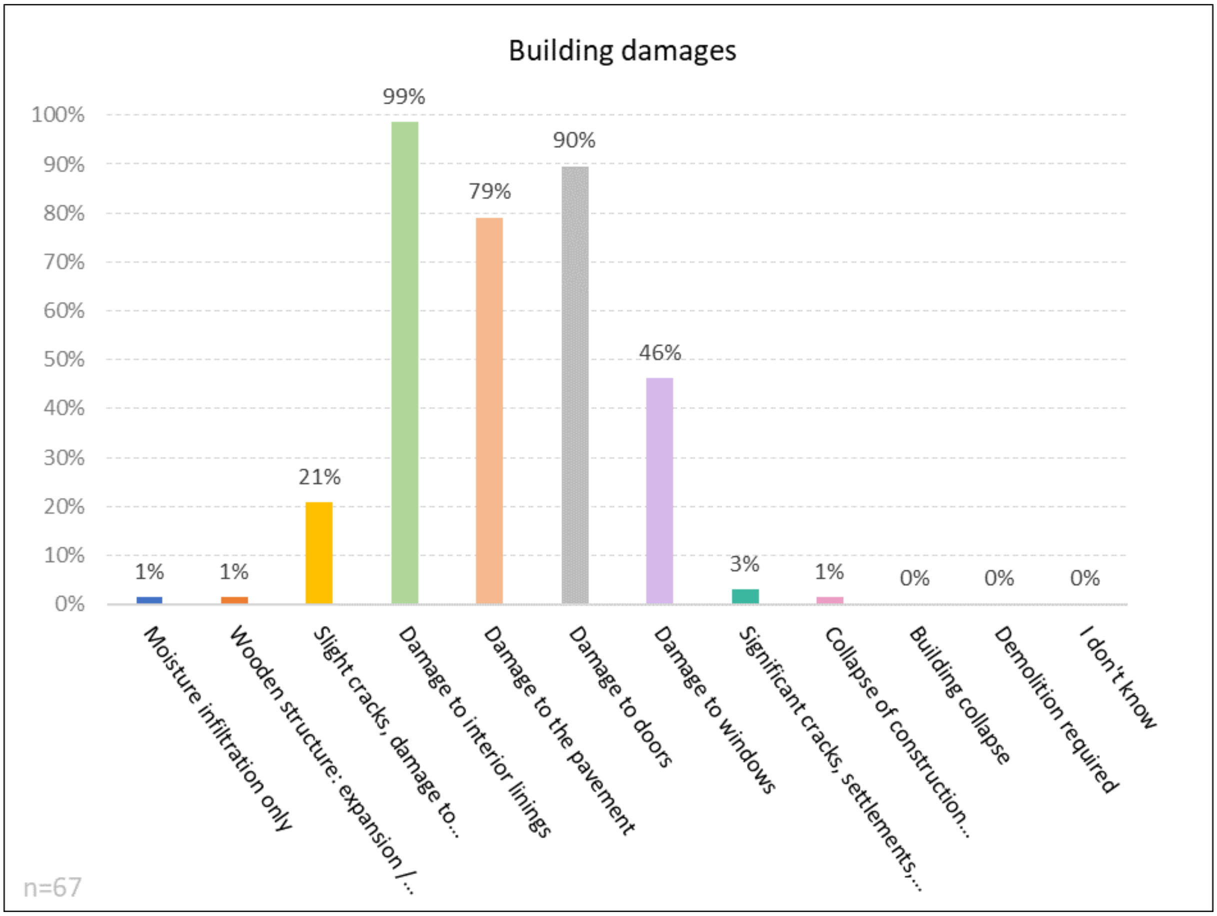



*Figure 33: Percentages of the types of damage which caused the flood at the homes of the participants, Belgium (questionnaire part 2 residential, question 44).*

The cause of the building damage is not solely attributed to the water levels, but also to its velocity, the percentage of sediments transported, the duration of the event, impact of floating objects, among others (Figure 34). These reasons depend on the building location and its surroundings.

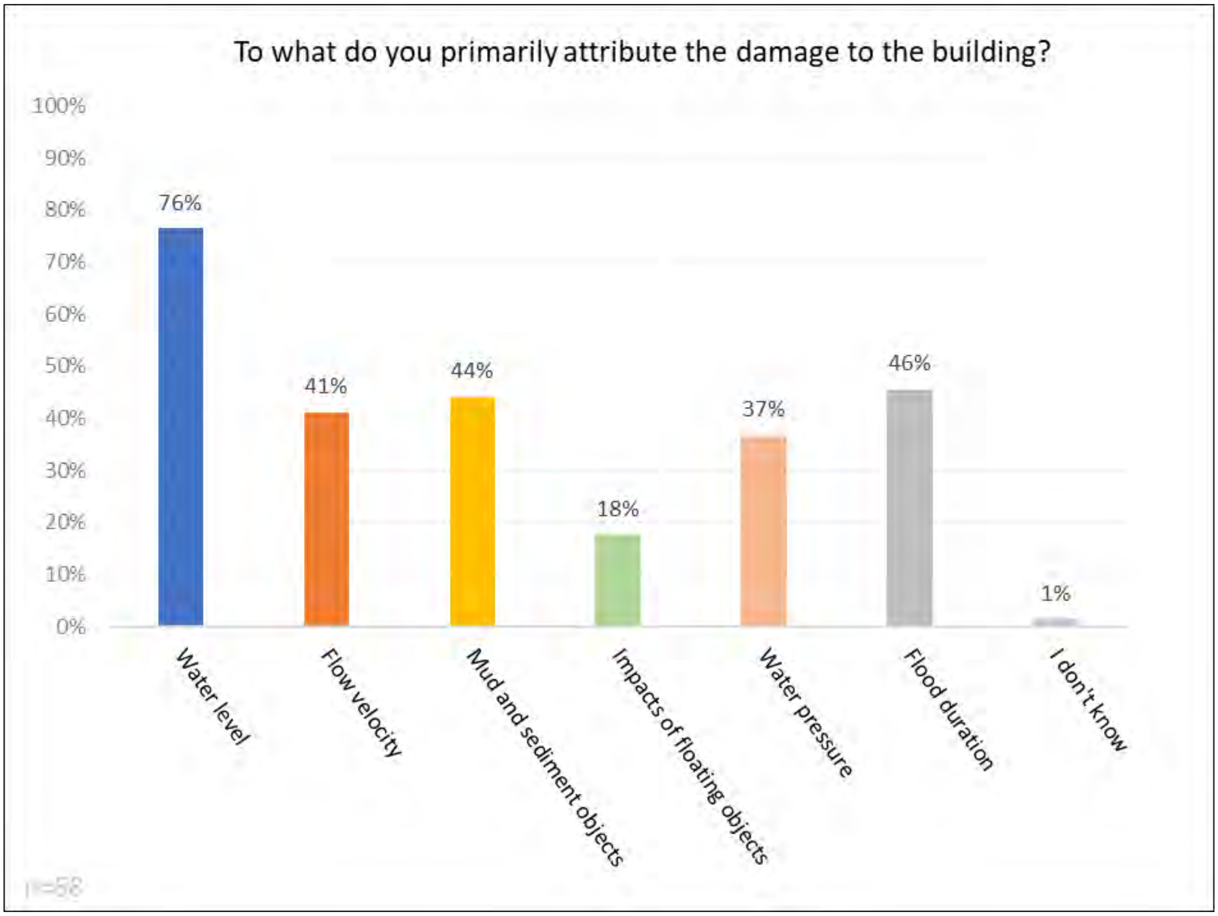



*Figure 34: Percentages of the causes to which the participants attribute the damages to their building, Belgium (questionnaire part 2 residential, question 49).*

The median building damage of the surveyed buildings amounted to approximately 53,000 euros (Figure 35). Furthermore, the survey enabled collecting data on monetary losses associated with specific building components. This includes damage to the systems (i.e., the heating, plumbing and electrical system) with an median reported value of 11,260 euros (Figure 158). Damage to interior walls carries a median cost of 7,400 euros (Figure 160), while the damage to windows and doors is estimated around 5,600 euros (Figure 160). Additionally, the expenses related to cleaning, decontamination and dehumidification have an average estimated cost of 2500 euros (Figure 163).

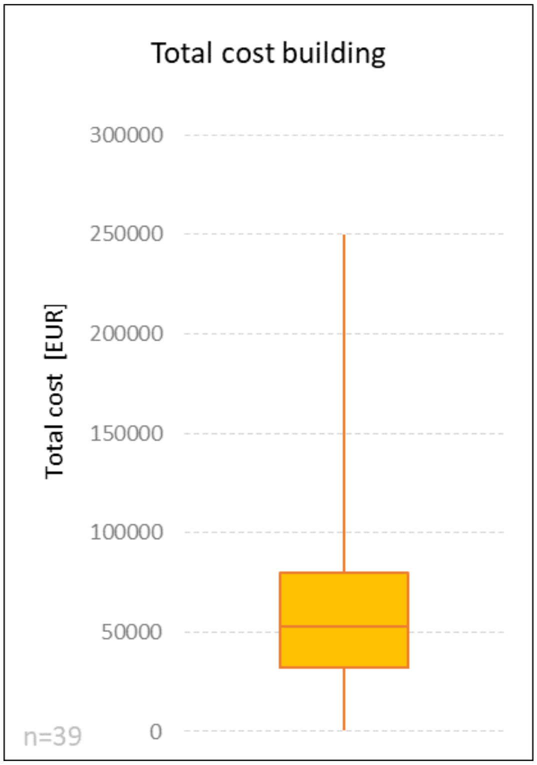



*Figure 35: Box plot of the total costs of all reparation work on and in the building (material and labor), Belgium (questionnaire part 2 residential, question 50).*

Apart from the building damage and its content, people were compelled to leave their houses because the living conditions became untenable following the flood. As illustrated in Figure 36, 76% of the respondents had to leave their home. This displacement lasted for an average period of three months, as shown in Figure 37. This evacuation resulted in additional indirect costs that individuals had to carry in the aftermath of the disaster.

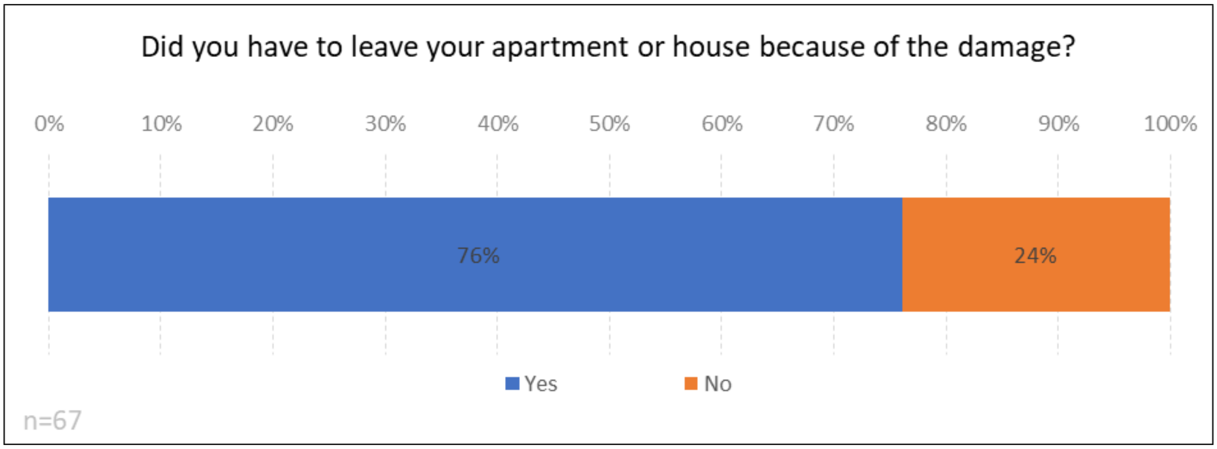



*Figure 36: Percentage of participants who had to leave their home because of the flood in July 2021, Belgium (questionnaire part 2 residential, question 62).*

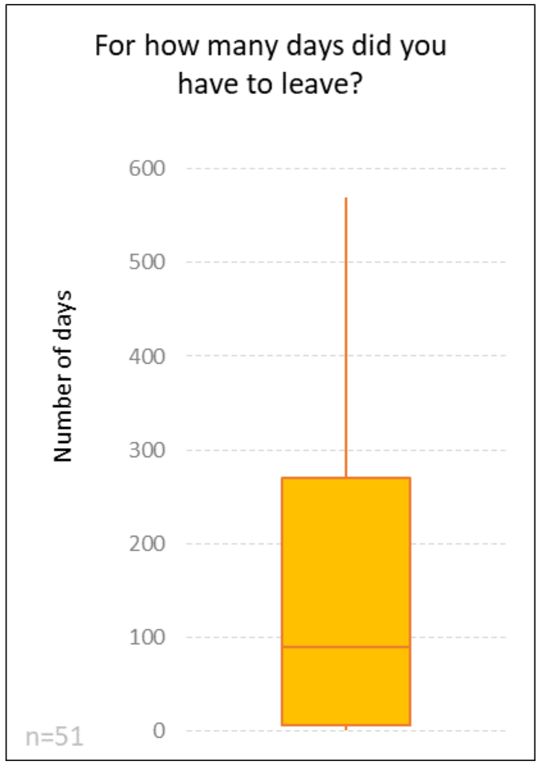



*Figure 37: Box plot of the number of days the participants had to leave their home because of the flood in July 2021, Belgium (questionnaire part 2 residential, question 63).*

In Belgium, the field surveys were carried out during the first months of 2023. This implies that approximately one year and a half after the flood event, only 55% of the people reported to have completely restored their dwellings (Figure 38). Regarding the household condition, the recovery has been a bit faster, with 64% of the respondents who report having fully recovered them (at least the one that can be retrieved). On average, it took around nine months from the time of the flood event to fully restore their household contents.

To help the affected population to cope with the costs incurred after the flood event, various forms of financial supports were provided. These supports included donations, rent and tax reductions, as well as compensation from insurance companies. On average, individuals received 73,000 Euros of compensation from insurance companies, as indicated in Figure 165. This amount aligns well with the estimated damages reported by the inhabitants, which were often determined by expert evaluations.

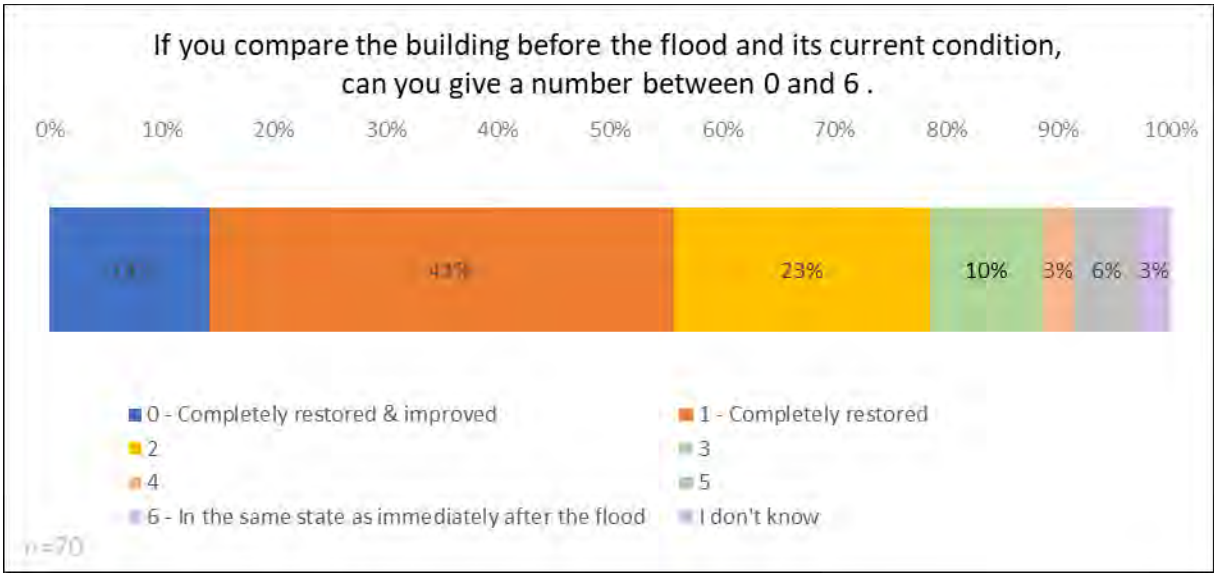



*Figure 38: Percentages of the assessment of the condition of the building, Belgium (questionnaire part 2 residential, question 64).*

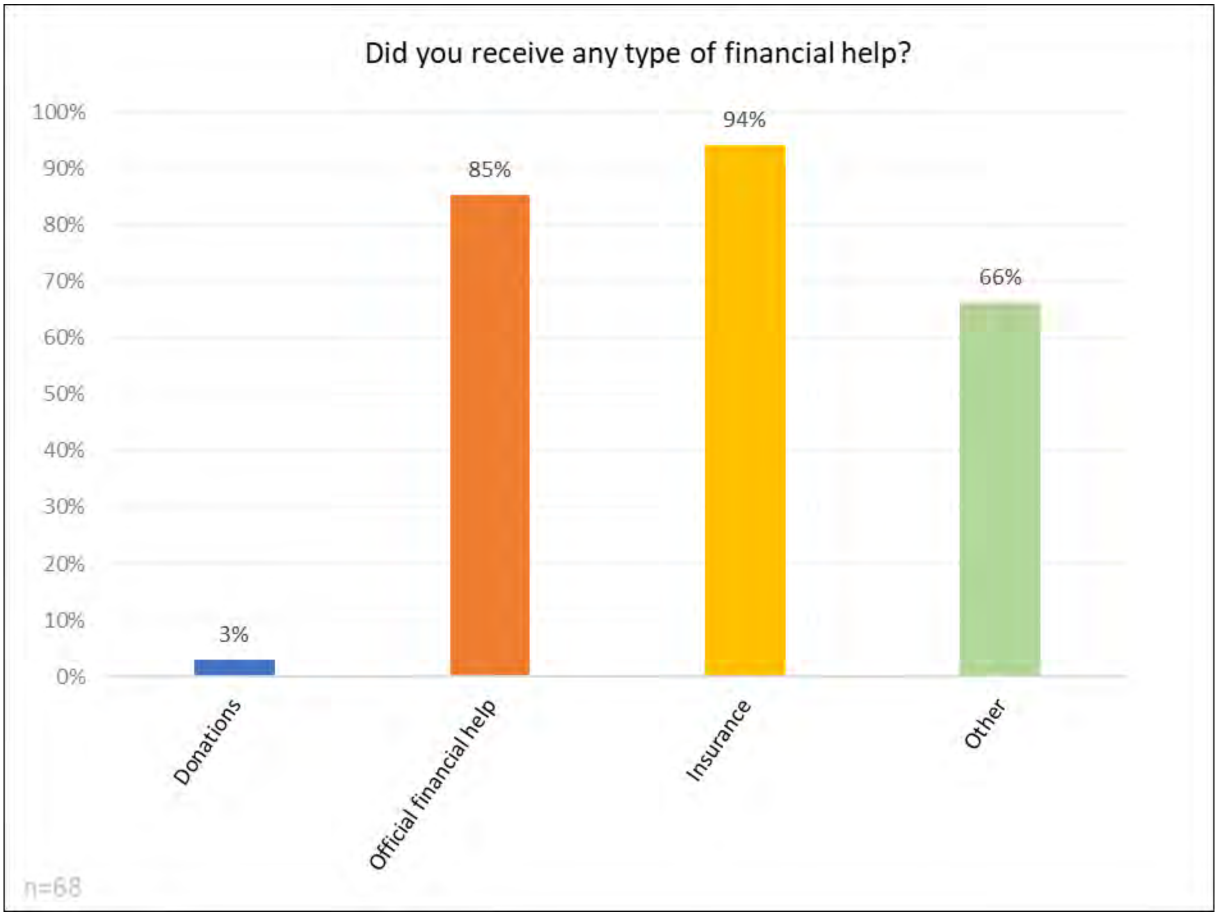



*Figure 39 : Percentage of types of financial help participants received, Belgium (questionnaire part 2 residential, question 66).*

## Coping capacity

When considering the population's response to the flood event, it's crucial to highlight the significance of early warning systems. These systems play a pivotal role in enabling people to take actions aimed at damage prevention or mitigation. For this purpose, a timely warning is of paramount importance, ensuring that there is sufficient lead time for the population to implement various protective measures.

Moreover, the clarity of the warning message is equally critical. Vague or ambiguous messages can give rise to assumptions and misunderstandings, potentially resulting in an ineffective warning. Therefore, it is imperative that warning messages provide specific instructions to guide the population on precisely what actions to take in response to the imminent threat.

In the Belgian case, the emergency response efforts were different from one municipality to the other. Therefore, the information collected to the survey regarding the response of emergency services are likely to specifically apply to the areas where the interviews were conducted and be of little relevance for other municipalities.

As depicted in Figure 40, 66% of the respondents in the surveyed districts report having received some form of warning before the event. However, in 65% of these cases, the warnings were based solely on personal observations, while in around 30% of cases, they came from neighbours or family members. Only 15% of the individuals who received advance notice, out of the 66%, received an official warning from authoritative sources such as BE-Alert (Official warning system), Infocrue (Official flood warning system), the fire brigade, or the police, as shown in Figure 166.

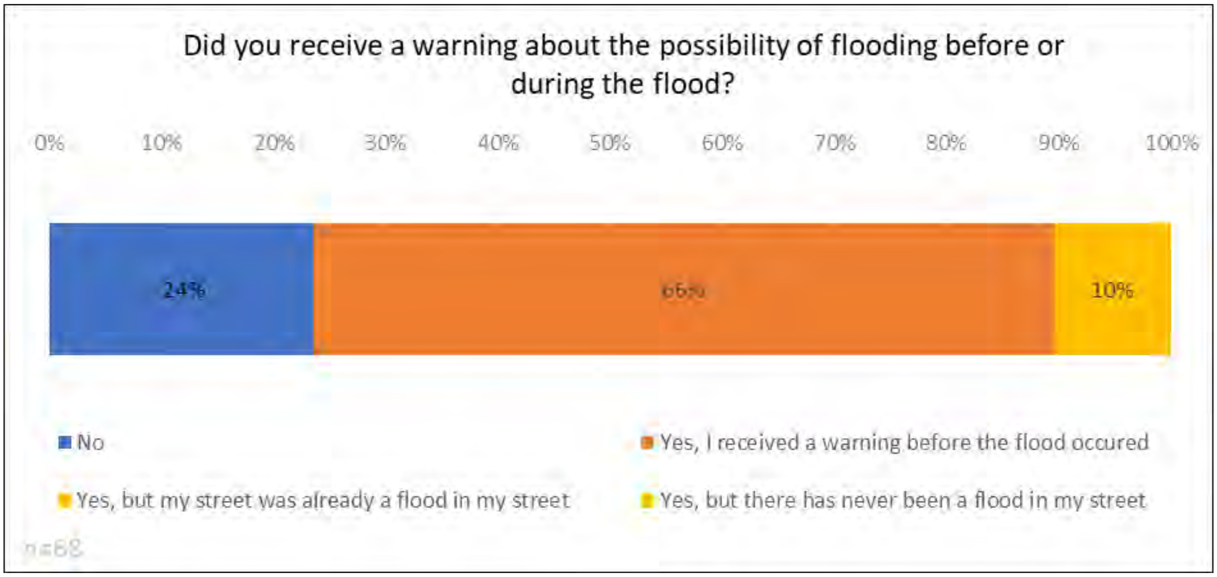



*Figure 40: Percentages of people who got a warning about the possibility of a flood or not and if yes, when, Belgium (questionnaire part 2 residential, question 76).*

The median lead time when respondents received the warning was approximately two hours before the flooding occurred, as indicated in Figure 167. In 58% of the cases, individuals took precautionary measures, as shown in Figure 168. These measures were typically implemented around one hour after receiving the warning.

Despite the potential risks and damage associated with an unprotected oil tank, as shown in Figure 171, most respondents could not protect the oil tank during the flood event, and they do not currently consider that protection as a feasible measure to be implemented.

The adoption of long-lasting measures, such as enhancing the building's stability or using waterproof materials, is still not under consideration for a significant portion of the population. Specifically, 100% of the respondents do not plan to improve the stability of their buildings, and 94% do not contemplate using waterproof materials. One of the contributing factors for this mindset is that 76% of individuals are planning to relocate, as indicated in Figure 41.

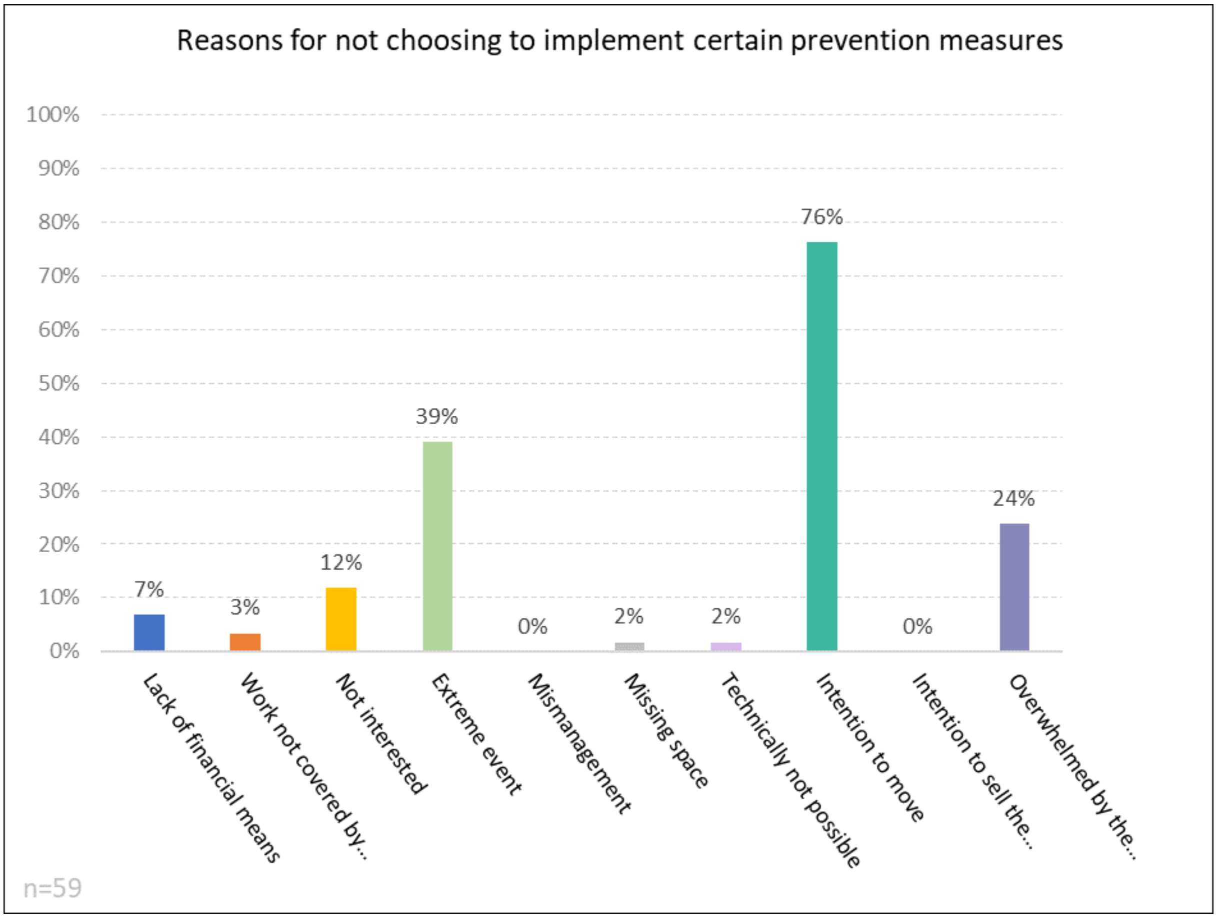



*Figure 41: Percentages of reasons, participants did not choose to implement certain prevention measures following the event, Belgium (questionnaire part 2 residential, question 84).*

Among the surveyed population, 94% of the respondents reported being covered by an insurance. In contrast, the registration rate with Belgium's National Crisis Centre (BE-Alert) at the time of the disaster was only 23%, with and an additional 11% having registered after the event. It is noteworthy that despite these measures being available, 66% of the people do not consider them to be important (Figure 170).

A striking 97% of individuals do not contemplate searching for ways to protect their homes in the event of another flood occurrence (Figure 170). This may be linked to the fact that 39% of them hold the belief that an event like the one in July 2021 will not happen again, as indicated in Figure 41. Part of the explanation for this perspective may stem from the severity of the previous flood event, which is apparent in Figure 42, showing that 69% of the population had never experienced a flood event before. This underscores the importance of updating flood hazard maps and effectively communicating the increased risk of flooding that the population now faces due to the changing climate conditions.

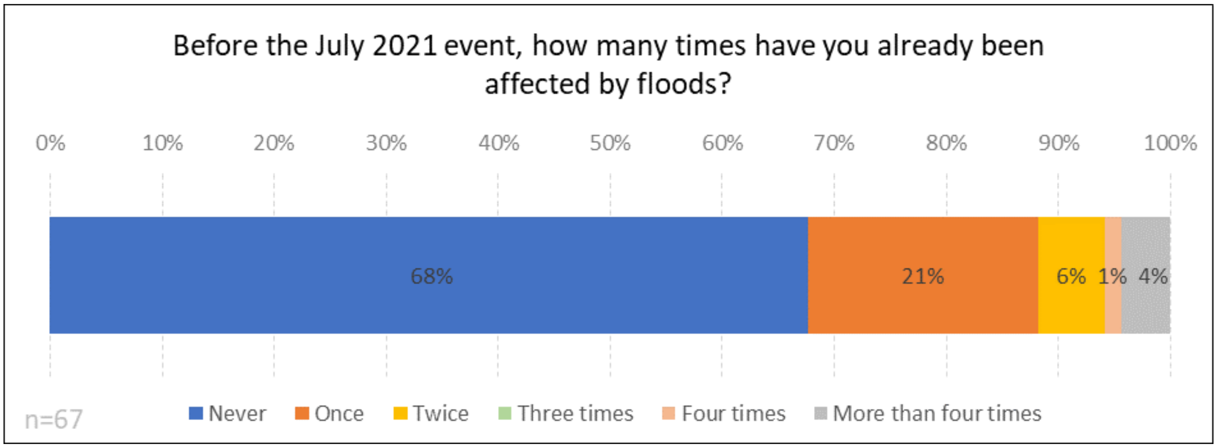



*Figure 42: Percentages of participants who were affected once or several times by a flood before the event in July 2021, Belgium (questionnaire part 2 residential, question 85).*

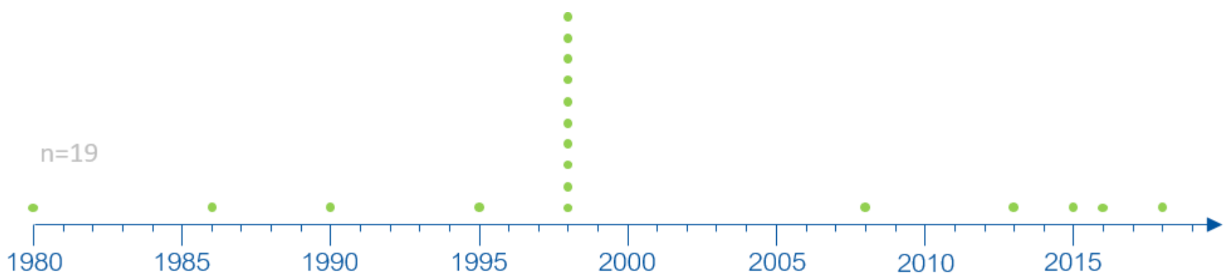



*Figure 43 : Year of the last time when participants were affected by floods before, Belgium (questionnaire part 2 residential, question 86).*

## 4.2 Germany

### 4.2.1 Survey statistics

380 doorbells were rung in the German survey area. 319 of them are located in the rural villages Zweifall and Vicht and 61 of them in the city Eschweiler. The participation rates in total and for each of these areas can be seen in Figure 44. A total of 49% of the doorbells that were rung were answered, which is nearly the half. In the diagram it can be seen that the participation rate in the rural areas is more than twice as high as in the urban area.

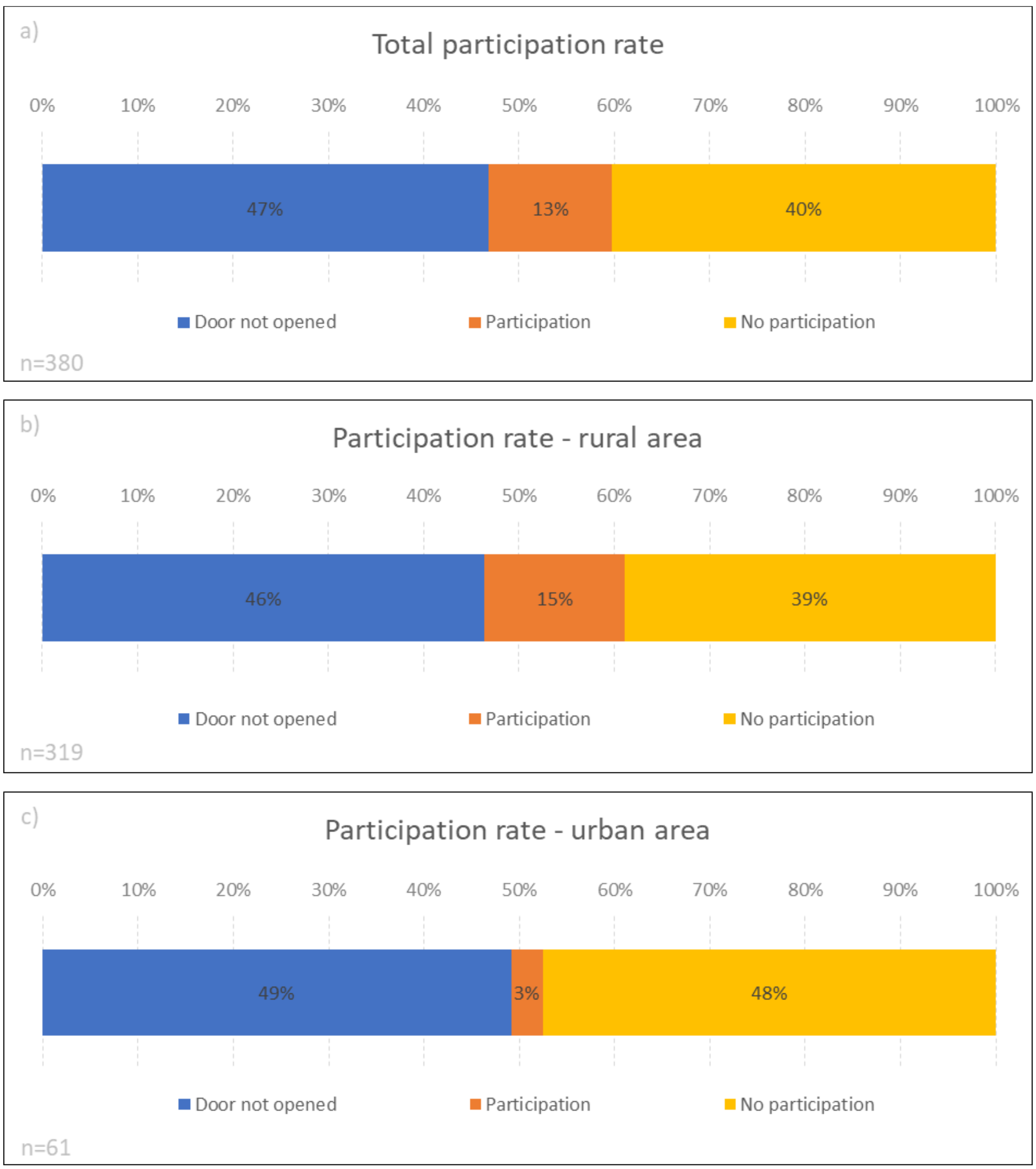



*Figure 44: Participation rates Germany a) total, b) rural area, c) urban area.*

Besides the 380 doorbells the survey team rang, 45 houses in the survey area were still abandoned and two were demolished due to flood damages. Furthermore, the reasons for which people did not participate were recorded. The percentage distribution is depicted in the diagram in Figure 45. The most frequent reason (42% 'lack of time' + 7% 'appointment' = 49%) is a lack of time. In these cases, the survey team asked the people for making an appointment, which was accepted by 7% of the people in total,

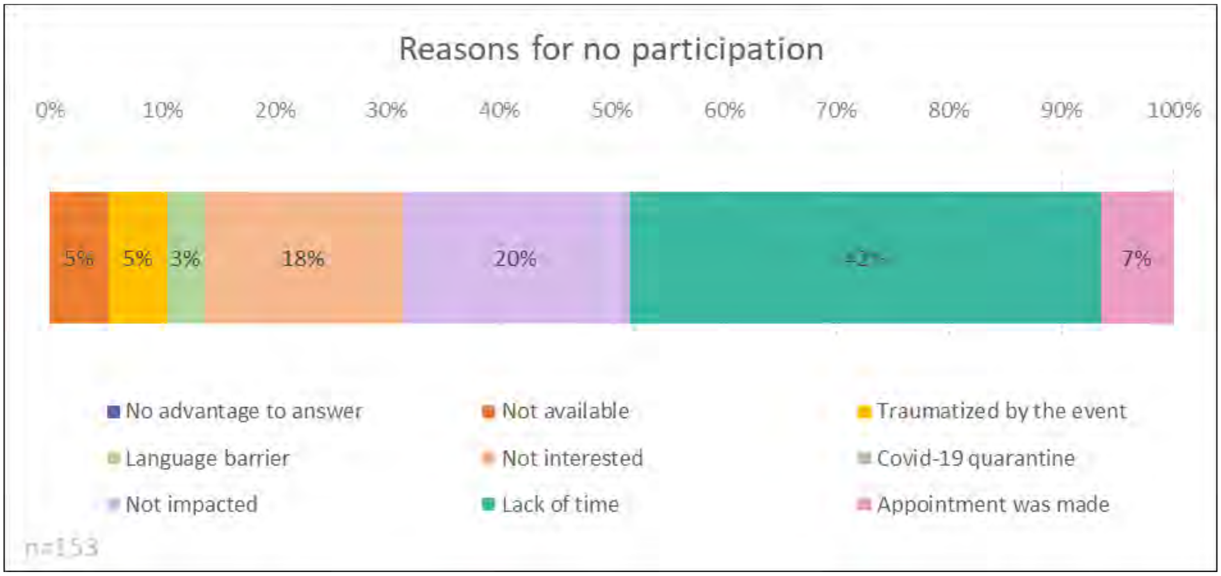



*Figure 45: Reasons for no participation, Germany.*

### 4.2.2 Part 1

In part 1 of the questionnaire the participants are asked about personal information. All the questions have a survey sample size of n = 70, what is the number of interviews conducted. Most interviews were conducted in the two rural villages Vicht and Zweifall (87% in total) as can be seen in Figure 46. 11% of the interviews were conducted in the city of Eschweiler and 1% in Weisweiler.

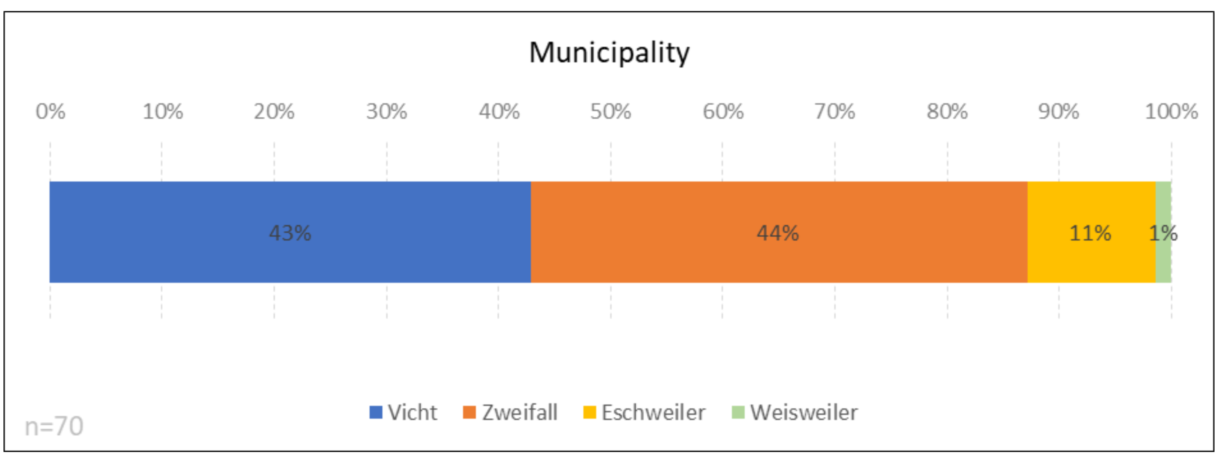



*Figure 46: Percentages of municipalities the participants live in, Germany (questionnaire part 1, question 2).*

Questions 10 and 11 ask about the level of education. If the answer to question 10 was ‘High school’, the participants in Germany were asked to precise this in a question 11, which differentiates between the three German Education Levels after visiting high school (Hauptschulabschluss/ Berufsbildungsreife, Realschulabschluss/Fachoberschulreife and Abitur/Fachabitur/Hochschulreife). The results are shown in Figure 47 a) and b). Most of the participants have one of these three educational qualifications (69%). The most frequent education level of the participants is the German Hauptschulabschluss/Berufsbildungsreife (33%). 28% have an educational degree from a college or university.

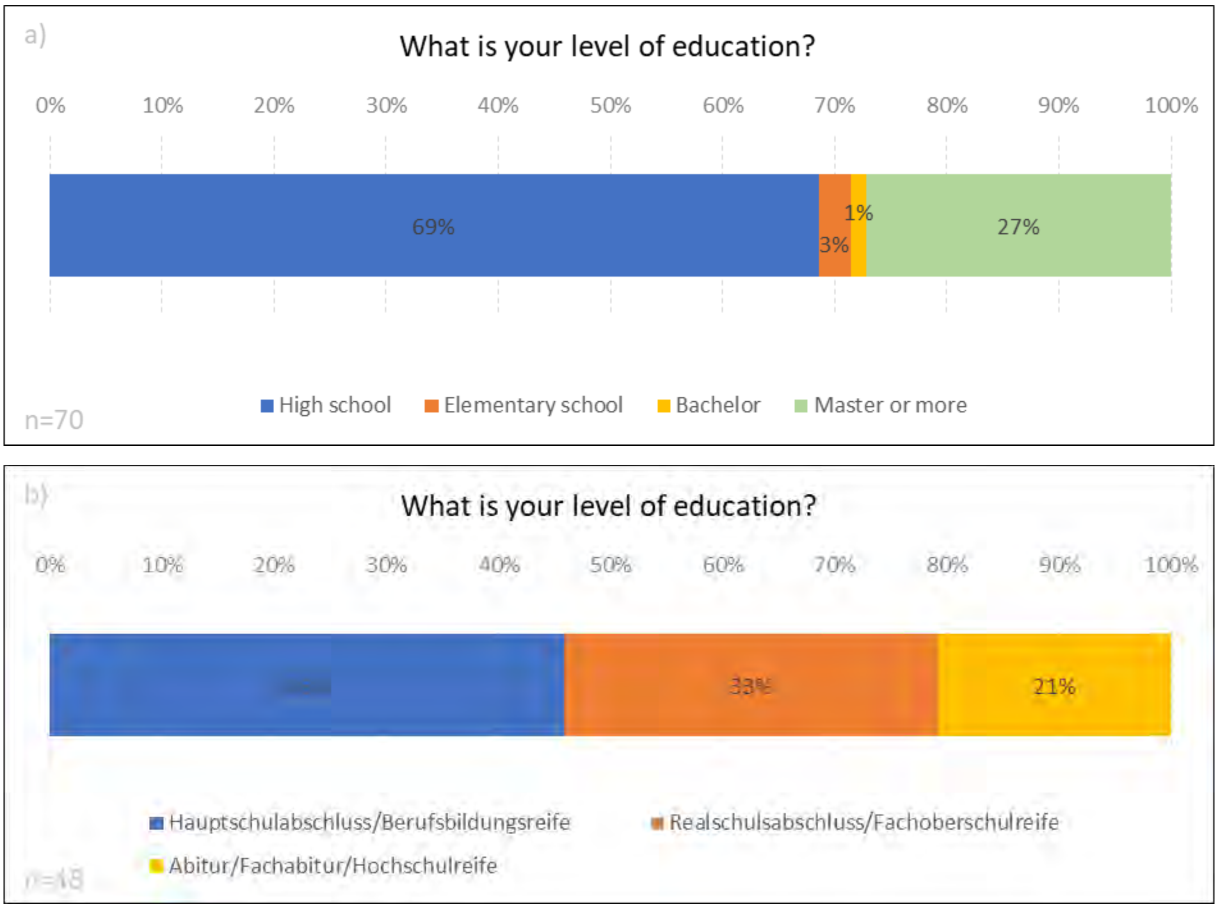



*Figure 47: Percentage of the level of education of the participants, Germany (questionnaire part 1, question 10-11).*

Questions 12 and 13 is about the socio-professional category of the participants. The results are shown in Figure 48 and Table 14. The most frequent socio-professional category is ‘retired’. The second most frequent answer was ‘other’. In this case participants were asked to name their profession/socio-professional category. The recorded answers to this are listed in Table 14.

As the interviews were held only during working days between 8:30 AM and 17:00 PM, the participants may not represent the average of the people affected by the flood in July 2021, because many people are at work during this time of the day. Probably this is the cause of the high percentage of retired people.

Other people we met were housewives (see Figure 48), people who worked from home or people were not allowed to work due to a pregnancy or an illness.

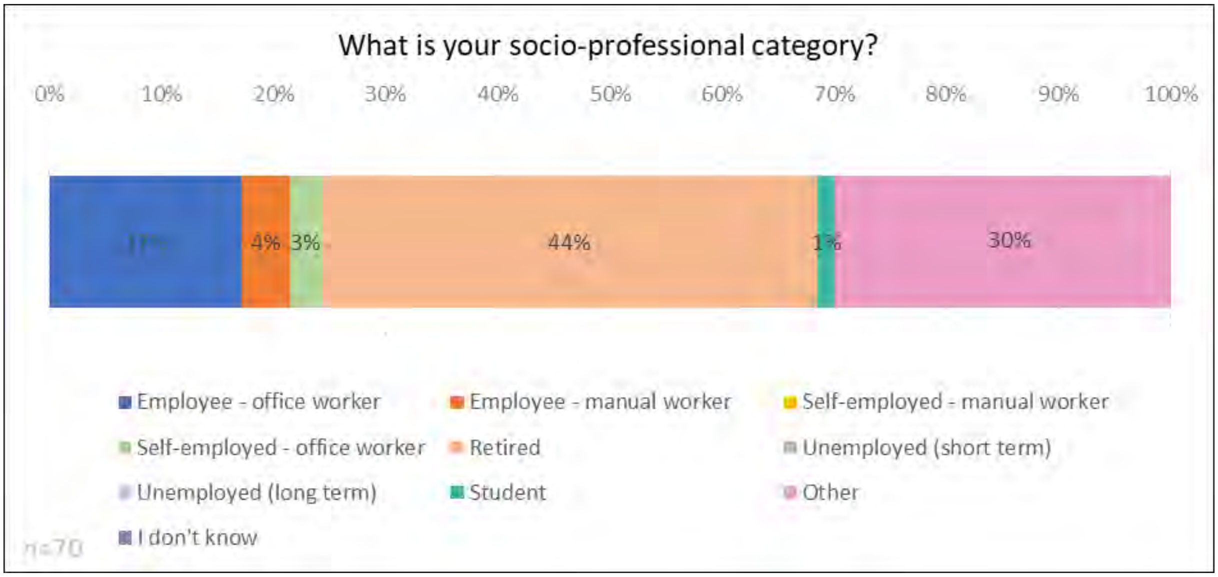



*Figure 48: Percentages of the socio-professional categories of the participants, Germany (questionnaire part 1, question 12).*

Participants were also asked whether they want to be kept informed about the progress of the study. 84% of them want to be kept informed (see Figure 174). These people gave their contact details in form of an e-mail address or their post address to the survey team.

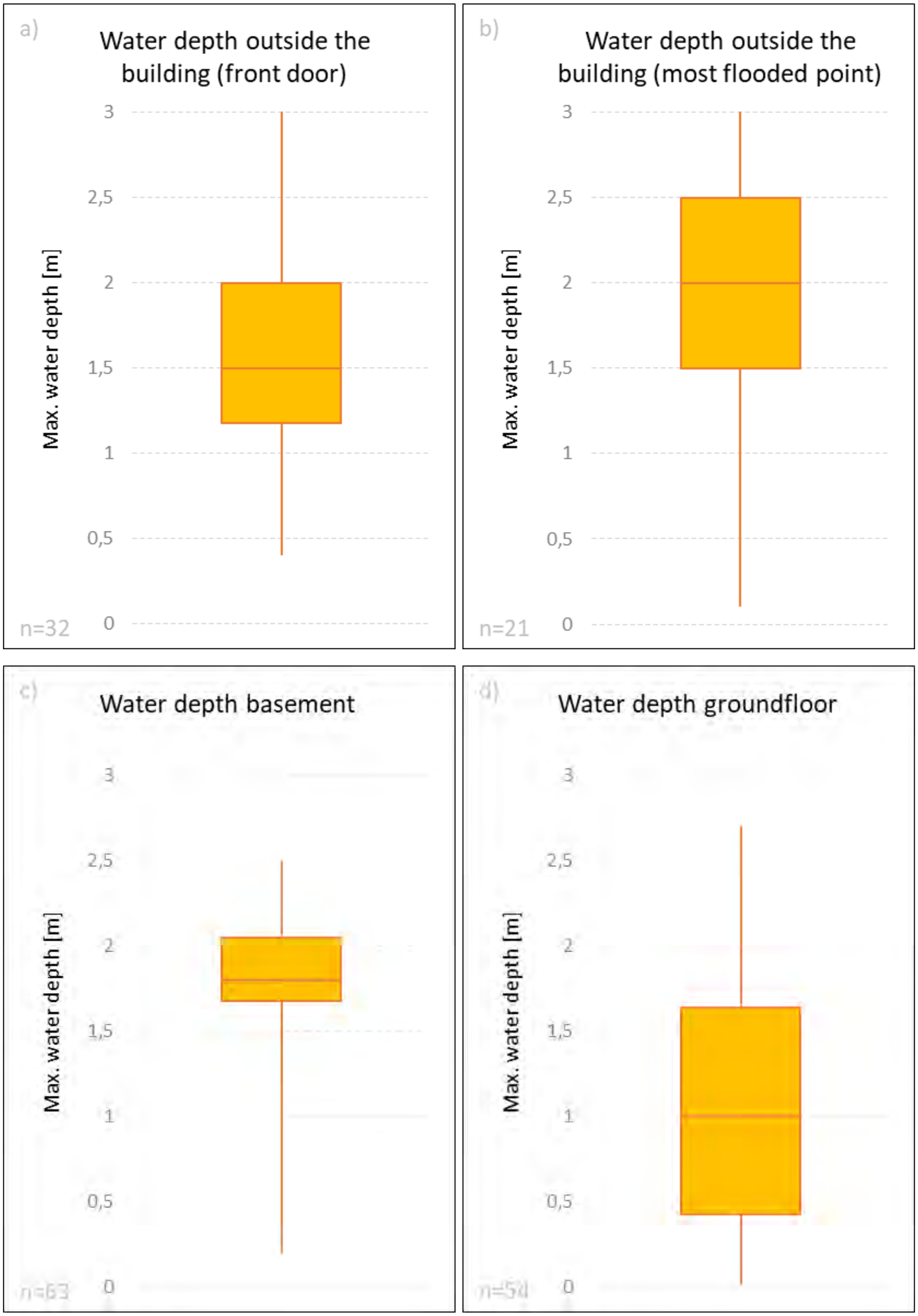
### 4.2.3 Part 2 (Residential sector)

From question 1 ('interview start time') and question 82 ('interview end time'), the duration of the interview can be calculated. The results of this can be seen in Figure 175. The shortest interview was only 21 minutes long and the longest interview lasted 162 minutes (= 02:42 h). The Median is 58 minutes.

It can be seen that the interview can be done in 20-25 minutes, if the dialogue contains only the questions and answers and people cannot give much information. Most times the interview is at least twice as long as the 20-25 minutes, because most people have much more to talk about the flood than what is asked in the questionnaire and tell their stories of the flood experience during the interviews.

Question 2 is about the type of the interview. From 70 interviews 97%, which equals 68 interviews, were conducted in field, what means at the homes of the participants (see Figure 176). Exceptionally two interviews were conducted via telephone. These were the first interviews, which were arranged through the spreading of the survey in the personal circle of the German survey team.

The third question of questionnaire part 2 asks about the maximum water depth and the date and time of the water arrival, of the maximum water depth and of the water leaving at five different locations. In this report only, the results of the maximum water depth are included (Figure 49). Comparing Figure 49 a) to Figure 49 b), it is noticeable, that the minimum value for the maximum water depth at the front door (a)) is higher than the minimum value for the maximum water depth at the most flooded point (b)), which looks like an inconsistency, but is due to the fact, that not all participants could give values for all locations of this question and henceforth the people who gave values for a) 'front door' are not inconclusively the same who gave values for b) 'most flooded point'. Through to this one can see, that the survey sample sizes are different for the 5 locations. The smallest survey sample size is given by e) 'first floor', what is due to the fact that only few people had water on the ground floor. Through the small survey sample size of n = 4 the validity of the e) is limited. The median maximum water depth of the flood in July 2021 at the participants home is 1.5 m outside the front door (a)), 2 m at the most flooded point outside the building (b)), 1.8 m in the basement (c)), 1.0 m on the ground floor (d)) and 0.7 m on the first floor (e)). The maximum water depths are highest outside the building at the front door (a)) and at the most flooded point (b)) with 3.00 m.


a)
Water depth outside the building (front door)
Max. water depth [m]
3
2,5
2
1,5
1
0,5
0
n=32
b)
Water depth outside the building (most flooded point)
Max. water depth [m]
3
2,5
2
1,5
1
0,5
0
n=21
c)
Water depth basement
Max. water depth [m]
3
2,5
2
1,5
1
0,5
0
n=63
d)
Water depth groundfloor
Max. water depth [m]
3
2,5
2
1,5
1
0,5
0
n=54

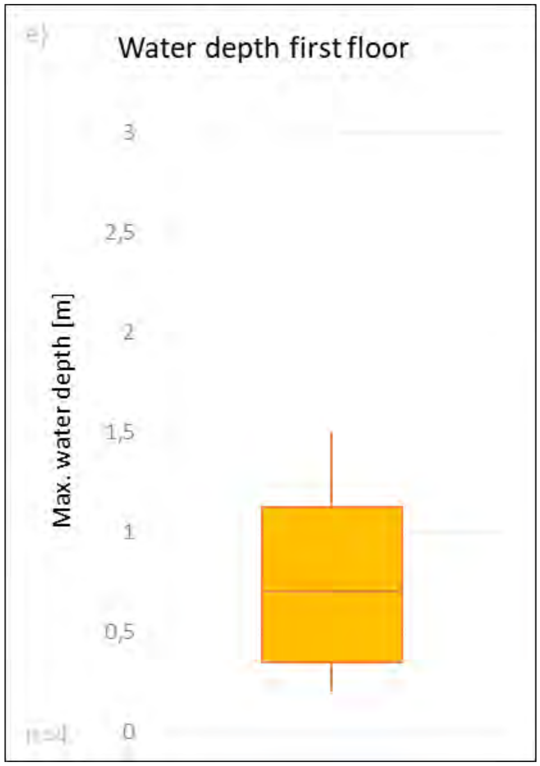



*Figure 49: Boxplots of the maximum water depth during the flood a) outside the building (front door), b) outside the building (most flooded point), c) in the basement and d) on the ground floor and e) on the first floor, Germany (questionnaire part 2 residential, question 3).*

As can be seen in Figure 177, 84% of the responding participants are owners of the buildings they live in. 1% of participants, which equals 1 participant, are owners of their housing unit. Only 14% are tenants.

Questions 5 and 6 are about the reasons that people attribute the flooding of their home. The results are depicted in Figure 50. The most frequent question is 'overflow of a watercourse'. The second most frequent answer is 'runoff' (39%). As in many houses the basements were flooded through the groundwater before the water from the rivers entered the buildings from street level, 30% of the 70 participants who answered this question gave 'groundwater flood' as a cause. 20% of them also mentioned one or multiple other cause(s) of flooding. These answers are listed in Table 15. As can be seen some participants blame the Dreilägerbach dam resp. their operators for the flooding. When interpreting this data, it must be considered, that the results of this question only show the participants opinion about the reason for the flooding of their home what is not necessarily the same. Although some participants have the opinion that the Dreilägerbach dam failed, which did not occur in the event in July 2021, as we are certain about since the survey team got the operator of the dam and got all available data of the dam from the days the flood event happened.

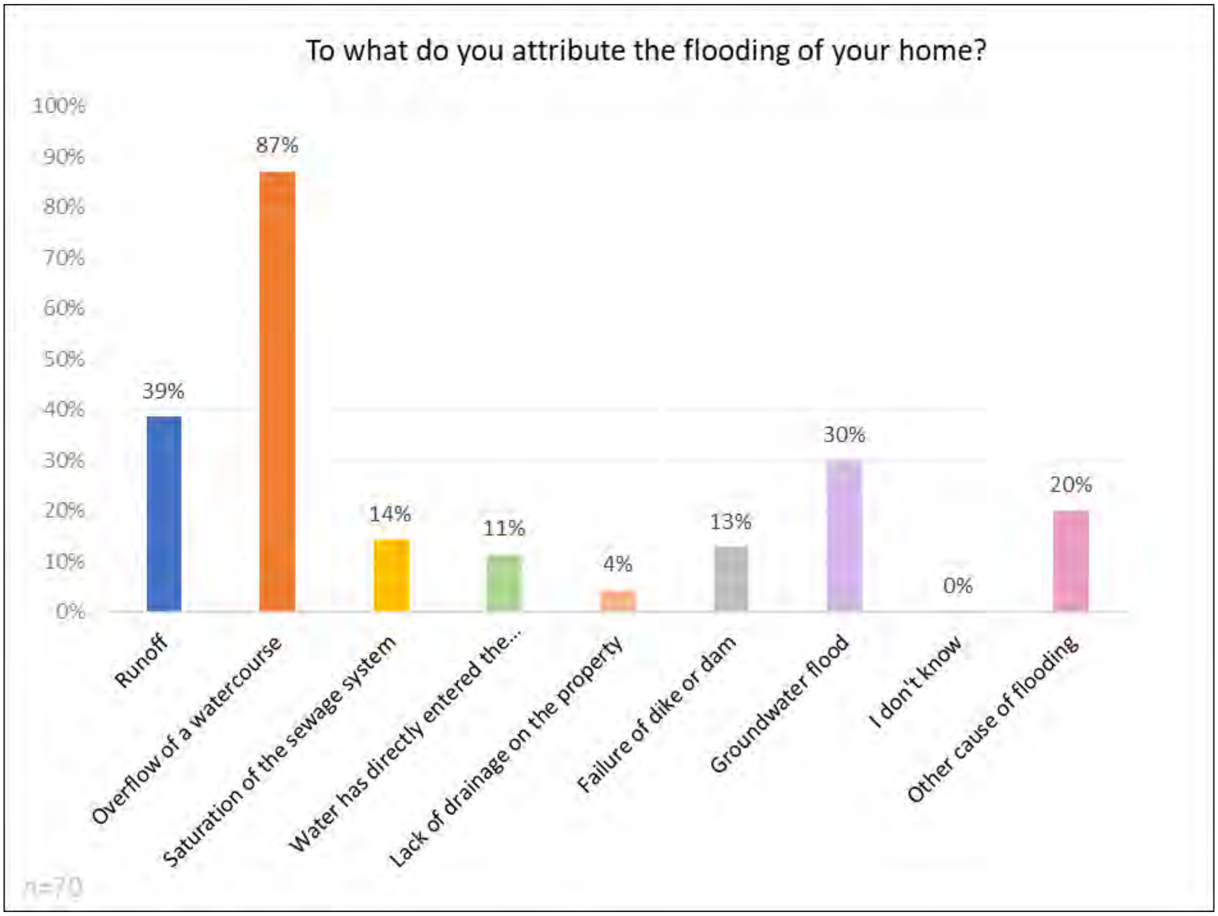



*Figure 50:Percentages of to what the participants attribute the flooding of their home, Germany (questionnaire part 2 residential, question 5).*

Question 7 (Figure 51) is about the subjective estimation of the magnitude of the discharge resp. the flow velocity. The participants were asked, if an average person could have been able to stand effortlessly in the flooded street in the immediate vicinity of their home. 71% of the answering participants (n = 67) said, that an average person would have been swept away by the current. 49% answered, that the water was too deep to stand, which matches the data from question 3 (Figure 49 a) and b)). None of the participants stated, that an average person could have easily stood in the vicinity of their house. And only 3% stated, that the person should have made efforts to stay upright. 10% could not give an estimation about this.

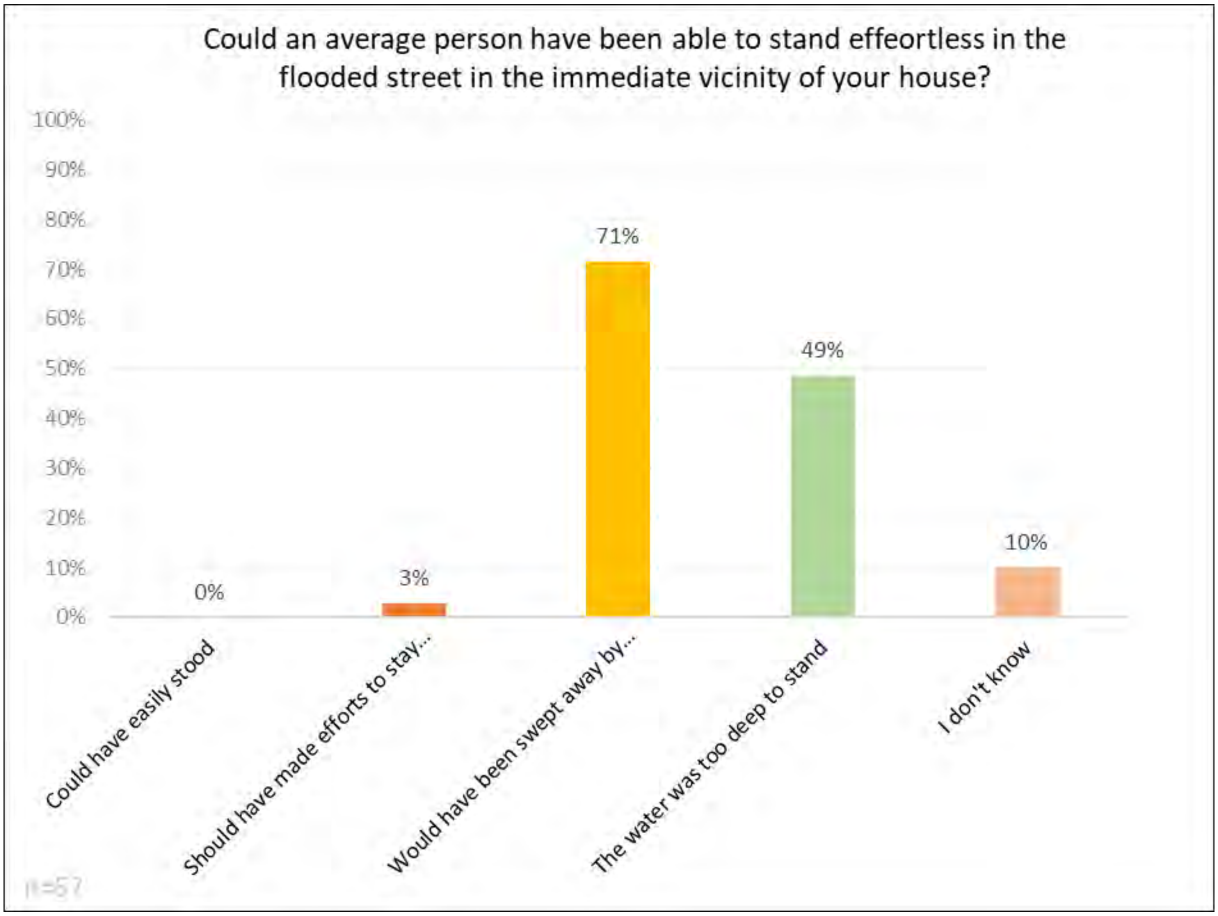



*Figure 51: Percentages of subjective estimates of the magnitude of the discharge/velocity of the participants, Germany (questionnaire part 2 residential, question 7).*

To be able to classify the water levels in the houses, which are given in Figure 49 (question 3), the elevation between the street level and the ground floor was estimated. The results of this are shown in Figure 178. According to this, the ground floor elevation is between 0.0 m and 1.7 m.

Figure 52 depicts, at which levels the homes of the participants are damaged. 91% of the respondents (n = 69) had damages in the basement, 78% had damages on the ground floor and 6% had damages on the first floor. None of the participants had damages on the higher floors. Regarding the finished levels of the building (question 10) no answers are availabe for Germany.

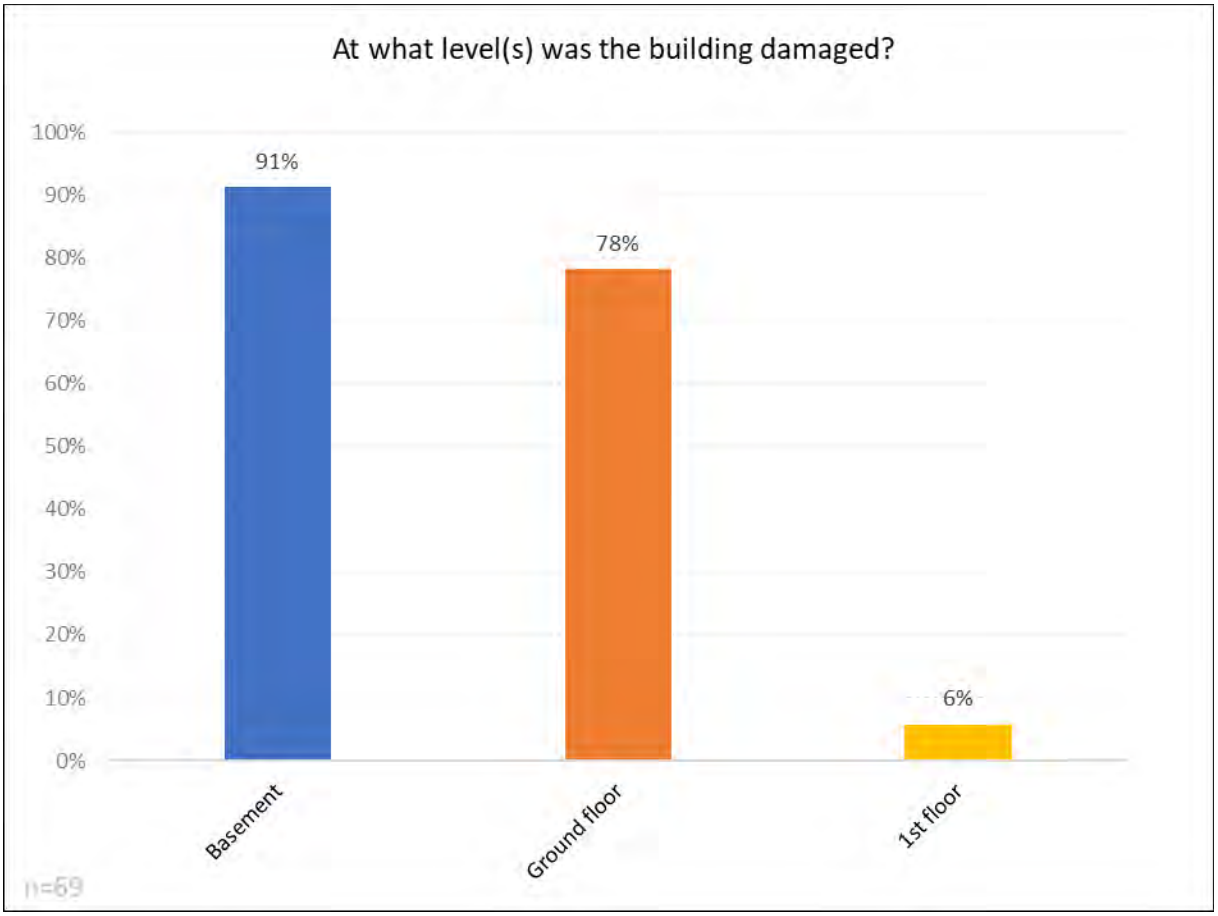



*Figure 52: Percentages of the levels, at which the homes of the participants are damaged, Germany (questionnaire part 2 residential, question 9).*

All 70 participants answered question 11, which is about the materials transported by the flood and deposited in or had direct contact to their homes. Regarding to Figure 53 mud was deposited in all participants homes and henceforth the most frequent material, followed by garbage (66%) and sand and stone (66%), vegetation (60%), rubble (53%), and large objects such as tanks or cars (54%). All of the respondents had either of these materials transported or deposited in the house nor observed a direct contact between these materials and the house.

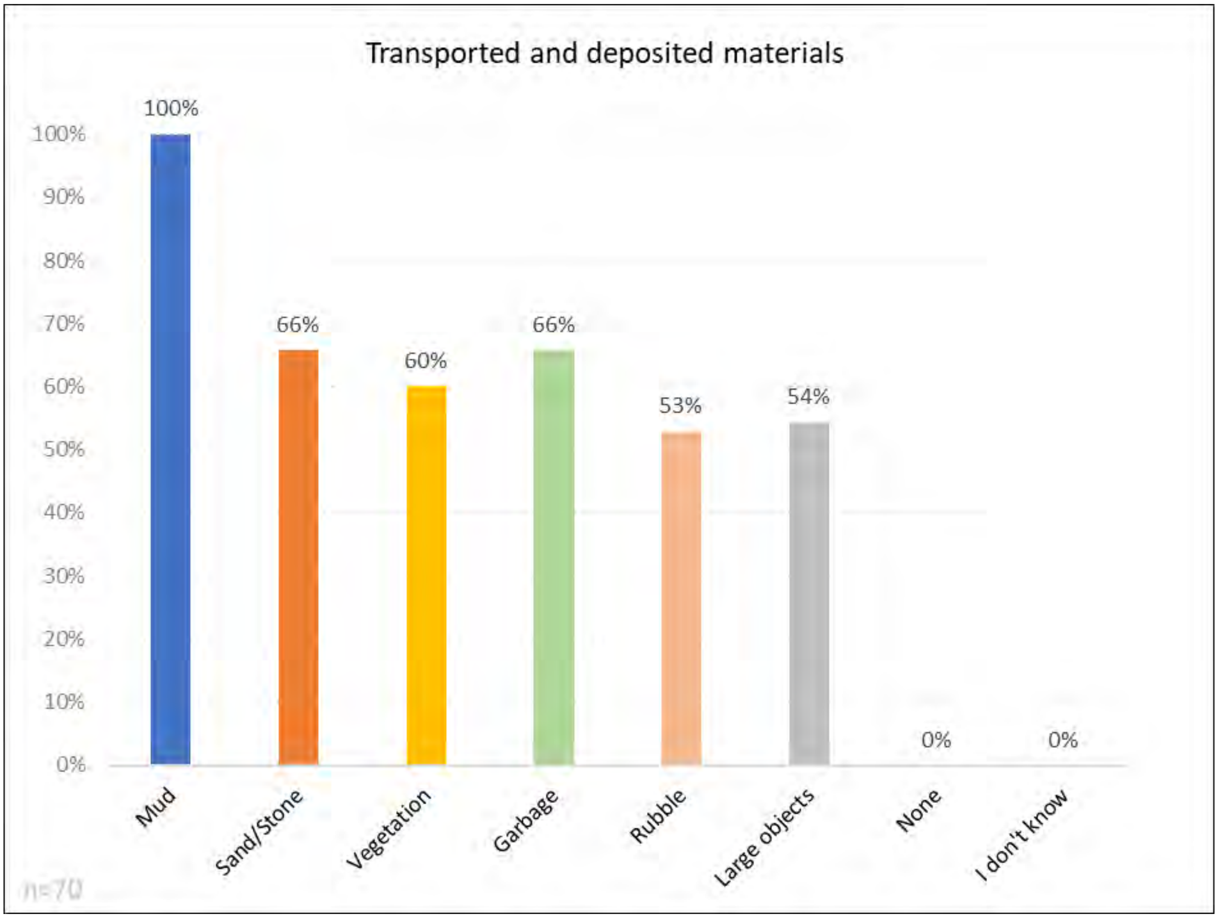



*Figure 53 : Percentages of what materials were transported or deposited in the buildings or had direct contact with them, Germany (questionnaire part 2 residential, question 11).*

In Figure 54 the box plot of the maximum sizes of the observed materials from question 11 (Figure 53) is shown. It can be seen that the largest object measures 15.00 m, which is significantly larger than the median of 3.5 m, while the smallest object is 0.5 m. As upstream to the villages of Zweifall and Vicht there was a campsite on the bank of the Vichtbach and most of the interviews were conducted in Zweifall, the people who ticked 'large objects' reported to the survey team mainly observed parts of caravans, such as a roof. Another frequent reported object was cars.

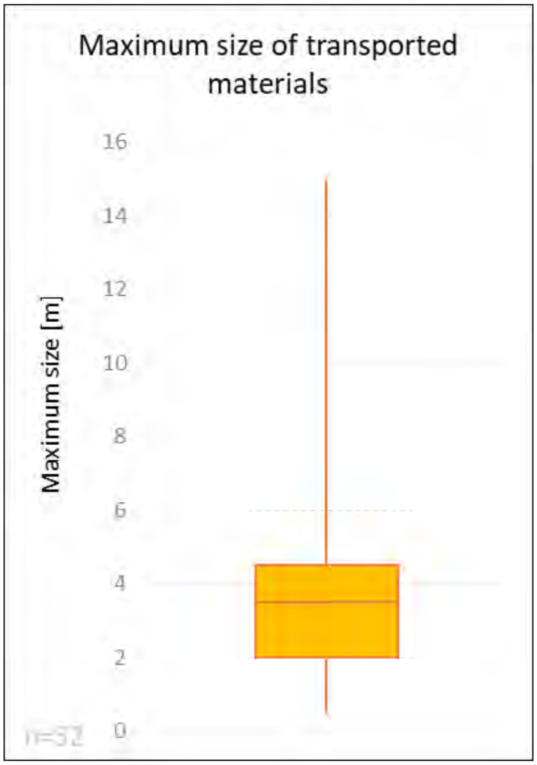



*Figure 54: Box plot of the maximum estimated size (length) of the transported/deposited materials in question 11, Germany (questionnaire part 2 residential, question 12).*

In question 13 (Figure 55) the participants were asked to categorise the strength of the water flow in the vicinity of their house on a scale from '1 = calm flow' to '6 = torrential flow'. The most frequent answer of the respondents (n = 57) was '6-torrential flow' (75%). 18% classified the water flow as a 5 on the given scale. 2% each stated a water flow strength of 2 and 3 and 4% categorised the flow as a '1-calm flow'. This matches the data of the subjective estimate of the flow strength in Figure 51 (question 7).

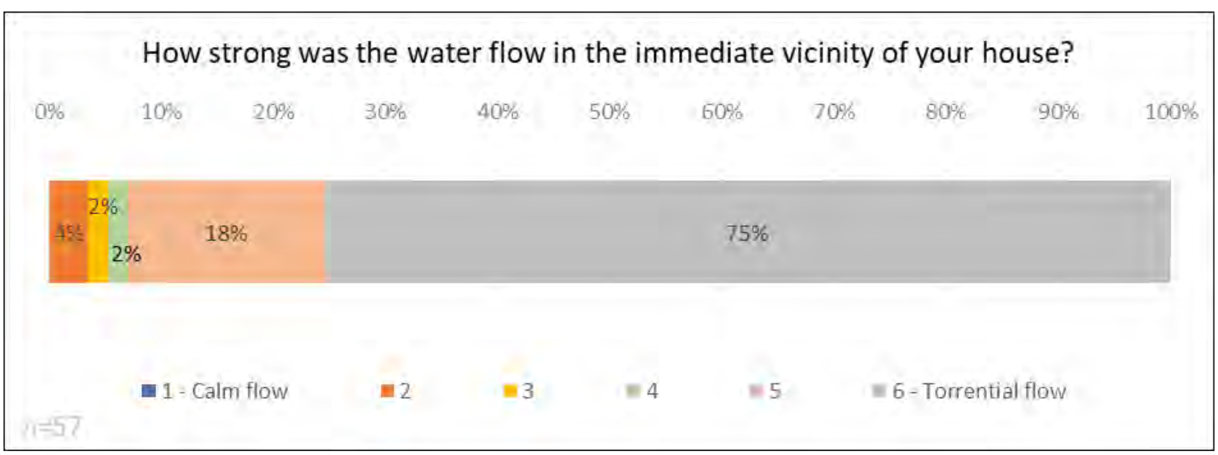



*Figure 55: Percentages of the estimation of the strength of the water flow in the direct vicinities of the participants homes, Germany (questionnaire part 2 residential, question 13).*

The next question (Figure 56) deals with the contamination of the participants house by sewage or faeces, hydrocarbons, or chemicals. 54% of the respondents (n = 67) stated, that their house had been contaminated by hydrocarbons, which happened because of leaking tanks from cars or heating oil tanks that had been damaged by the flood. 39% of the people didn't observe any contaminations. 36% observed contaminations with sewage or faeces and 9% with chemicals, paints, or varnishes.

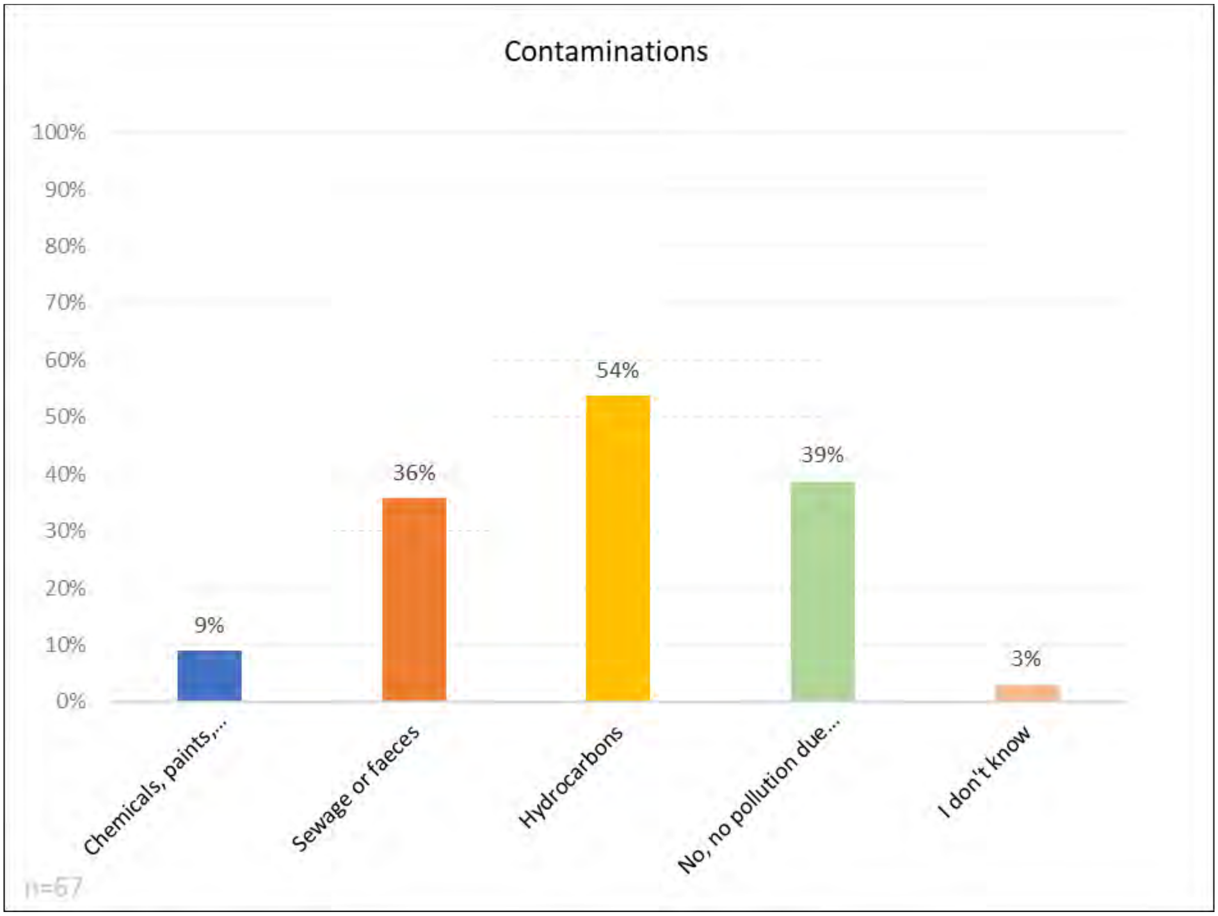



*Figure 56: Percentages of the records of the observed contaminants in the homes of the participants, Germany (questionnaire part 2 residential, question 14).*

As can be seen in Figure 179 the ground floor size of the 27 respondents varies between 20 m² and 280 m². The median is 70 m² and the mean value is 76 m². In Figure 180 the household items participants did need to replace after the flood are listed. It can be seen, which percentage of participants needed to replace which of the items. The most frequent household item people needed to replace were tools. This seems to be due to the fact, that most people keep their tools in the basement, which was the most flooded and damaged level (see Figure 49 c)) and Figure 52). Other frequently damaged items are other electrical appliances (than mentioned in this list), refrigerator/freezer and other electrical appliances. All these are also items often kept in the basement.

Other voluminous or expensive items participants lost in the floods are listed in Table 16. The most extraordinary item recorded is the professional equipment for five sled dogs.

Figure 181 shows the percentages of participants who had a car or motorcycle that was impacted by the flood. Most people did not have any of these impacted. 40% of the participants had one or more car(s) impacted by the flood. So had 16% one or more motorcycles.

In Figure 57 the box plot of the total costs of damaged household contents is shown. It can be seen that it varies between 1,000 € and 200,000 €. The median is 25,000 € and the mean value is 39,819 €. 75% had costs ≤ 5000 €. As can be seen in Figure 182 the stated value mostly is based on own estimations. Figure 183 shows the percentage of cases in which the compensation procedure is over. In 38% of cases the costs can still change. But as only 8 participants answered this question, the results of this question are not very reliable.

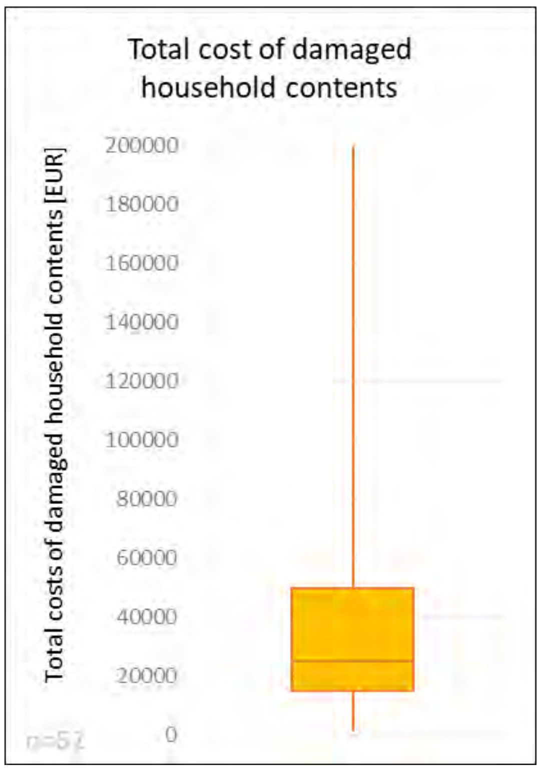



*Figure 57: Box plot of the total costs of damaged household contents of the participants, Germany (questionnaire part 2 residential, question 19).*

In question 24 (Figure 58) people were asked to classify the completeness of their households on a scale from ‘1-fully functional’ to ‘6-household items still have significant defects of shortcomings’. 59% of the responding participants (n = 66) answered, that their household is fully functional again. 38% of the answers are distributed to classes 2-5 and 3% answered, that their household still has significant defects or shortcomings.

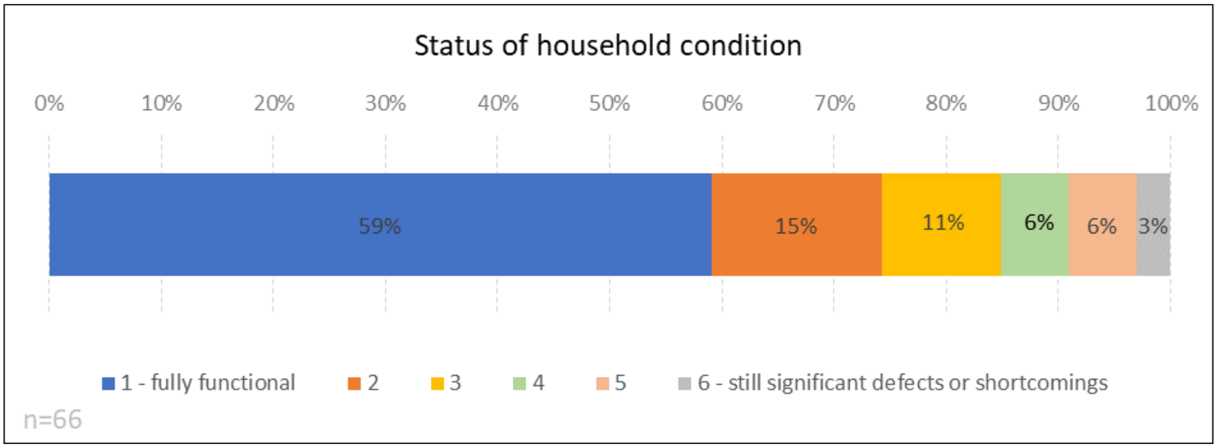



*Figure 58 : Percentages of people who ranked the status of their household's condition in the different categories, Germany (questionnaire part 2 residential, question 24).*

The people who said that their household was fully functional again, additionally were asked about the months it took to get to this condition. The statistical results are shown in the boxplot of Figure 59. It can be seen that the time lied between one and 18 months. The median is eight months.

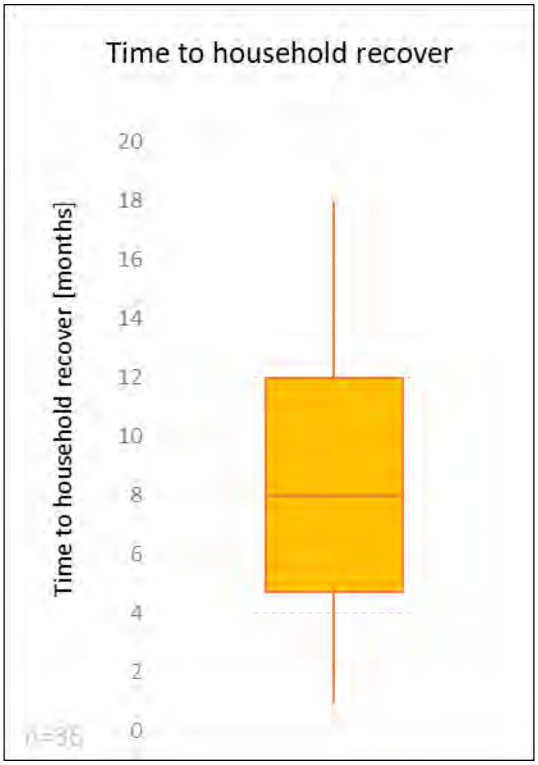



*Figure 59: Box plot of the number of months the household of the participants needed to fully recover, Germany (questionnaire part 2 residential, question 25).*

Questions 26-33 are about characteristics of the building. As can be seen in Figure 184, detached (37%) and semi-detached houses (40%) are the most frequent. Attached houses reached 16%. The least frequent answer was ‘apartment block’ with 7%. Figure 185 shows, that 61% of the buildings have four levels, including the basement, the ground floor, upper floors, and the attic. Further 23% have three levels. In 11% of the cases the buildings had 5 levels and in 4% 2 levels. None of the buildings had one level or more than 5 levels. Figure 186 a) to c) show the results to question 29 about the construction method of the different building levels. On all building levels the most frequent construction level is natural stone. Old houses from natural stone often occur in the villages of Zweifall and Vicht. All other construction methods occur in the single digits. It also can be seen that a huge part of the participants could not give a definite answer to this question. Other mentioned construction methods than suggested in question 29 can be seen in Table 17. The most frequent other construction methods are ‘brick masonry’ and ‘sand-limestone masonry’.

In question 31 (Figure 187) participants were asked how their basement rooms were used before the flood in July 2021. Most common was the usage of the basement rooms as storage room (83%) followed by the usage for laundry (53%) closely flowed by ‘boiler room, technical installations’ (48%), ‘storage room (wine, food etc.)’ (47%), ‘drying rom’ (35%) and ‘work/recreation room’ (33%). Other uses could be named in question 32. The only other use that was mentioned was ‘bathroom’ (Table 18).

The building period of the participants homes was recorded as well and is shown in Figure 60. More than the half (66%) of the buildings were built before the end of World War II in 1945. This is because most interviews were conducted in the villages Zweifall and Vicht, which, compared to most parts of the Eifel, experienced exceptional little destruction in World War II. Exceptionally high is the number of buildings which were built even before the end of World War I in 1918 (53%). Zweifall holds a lot of historic buildings. 19% of the buildings were built in the period after World War II (1946-1970). Only 14% of the buildings were built after 1970.

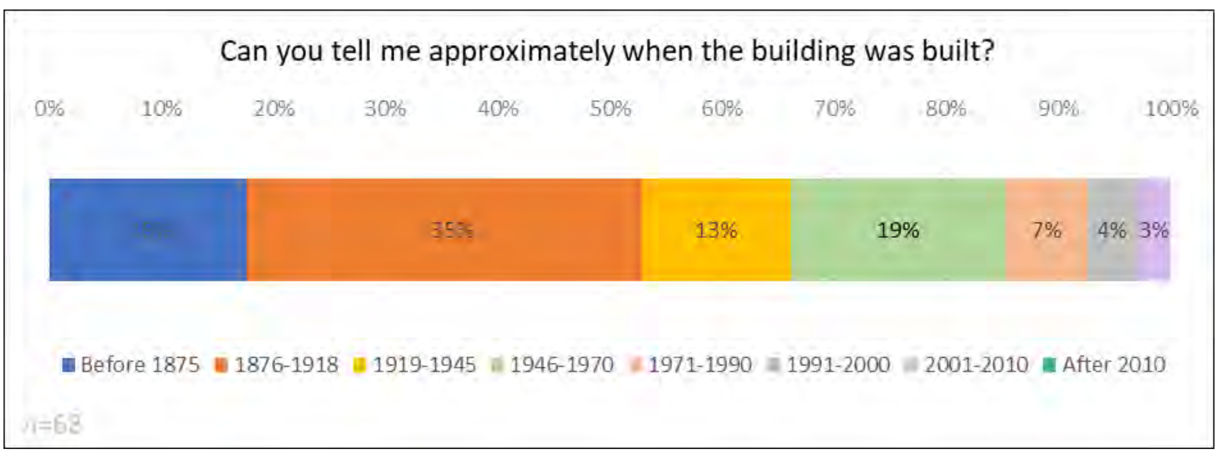



*Figure 60: Building period of the buildings the participants live in, Germany (questionnaire part 2 residential, question 33).*

Figure 61 shows a timeline with the years of the last major renovation before the flood in July 2021 of the participants homes. It can be seen that most of the last major renovations took place after 2005. It also can be seen that six of the 49 responding participants (12%) just renovated their homes in 2020 or 2021. These people reported, that as many others, they used the period during Covid-19 restrictions to renovate their homes.

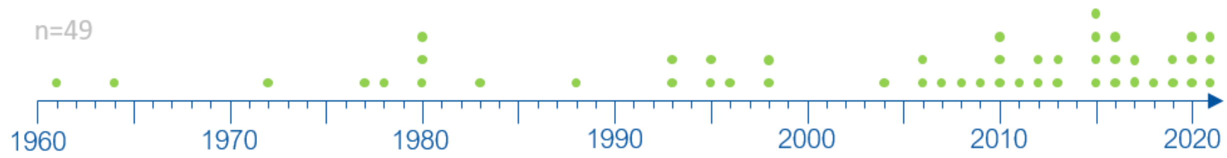



*Figure 61: Year of last renovation, Germany (questionnaire part 2 residential, question 34).*

As can be seen in Figure 188 64% of the respondents (n = 70) had gas heating before the July 2021 flood. Further 21% had oil heating, what caused contaminations with hydrocarbons in cases where the tank was damaged by the flood (see Figure 56, question 14). 9% had a pellet or wood chip heating or wood heating and 6% had electrical heating or night storage heating. 6% had another oil heating. Which could be named in question 32 (see Table 19). For example, there was an elderly lady who lives on the ground floor as a tenant and had oil stoves in every room which must be filled with oil from a can every day.

As can be seen in Figure 62 the heating system was located in the basement in most cases (53%). Another 25% of the participants had the heating system located on the ground floor before the flood. In 4% of the cases the heating system was located in each level/each apartment and in each 3% of the cases on the first floor or outside the building/in the annex. 7% had the heating system located anywhere else (see Table 20). One of the two answers was that there was no central heating system and the other one was the elderly lady with the oil stoves, mentioned in question 35.

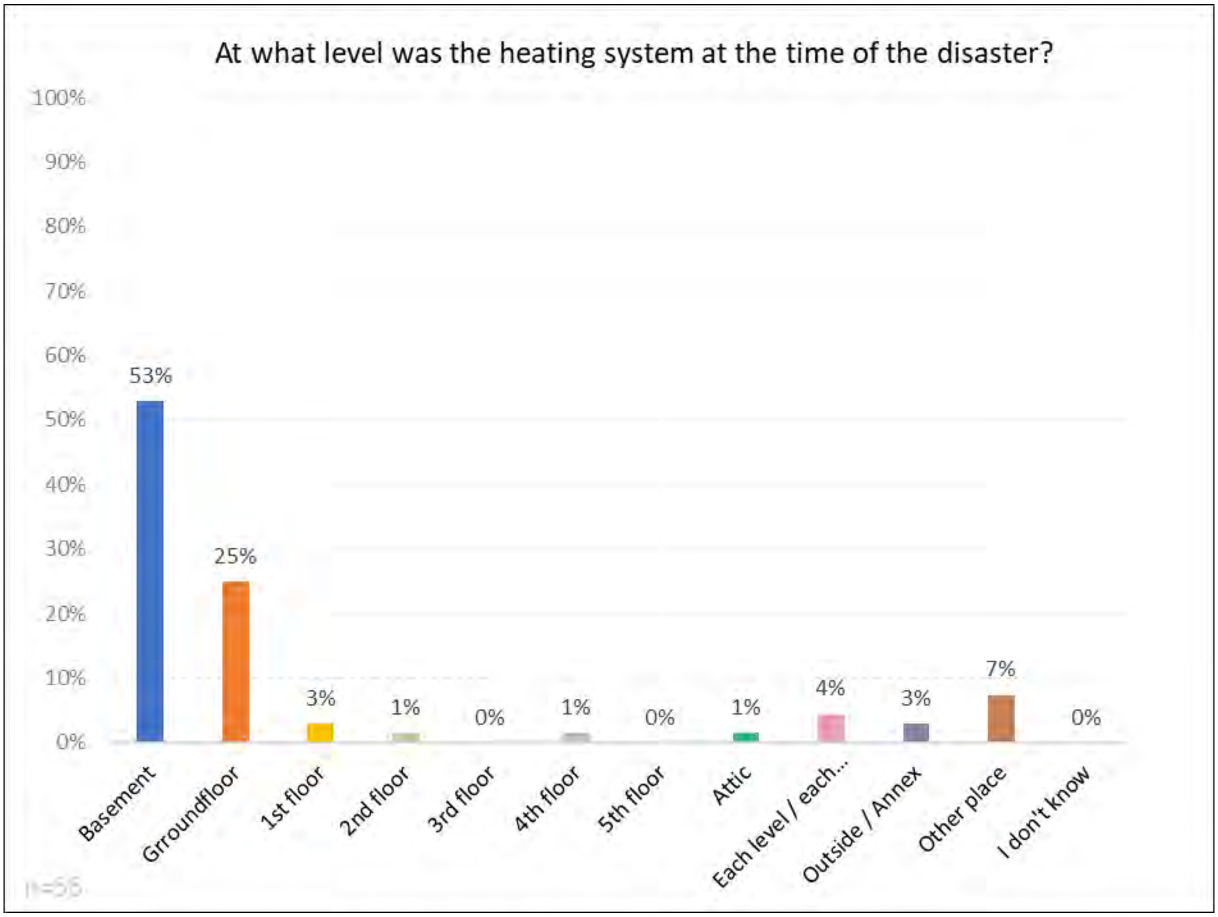



*Figure 62: Percentages of at which the heating system was located before the flood, Germany (questionnaire part 2 residential, question 37).*

Questions 39-42 of the questionnaire are related to the cost for repairing the heating system, the electrical system and the plumbing and sanitation system. It was possible to give values for each system separated (Figure 189) or for all systems in total (Figure 190). It can be seen in Figure 189 a), that the median of the cost for the heating system repair is 10,000 €. The maximum is 45,000 € and the minimum 2,000 €. The great differences occur due to the fact, that some people had only minor damages and hence minor repairs to the heating system whereas other people had to replace the heating system completely, in which the cost depends on several factors like the size of the building and the type of the heating system. The cost for the electrical system varies between 500 € for people who have friends who did the repairing or the craft company was directly paid by donations and 20,000 € for people who needed a fully new electrical system for the whole house (Figure 189 b). For the repairing of the sanitation and plumbing system the cost varies between 200 € and 24,000 € (Figure 189 c). Regarding the reliability of the data, it must be taken into account, that the survey sample sizes of the results of question 39-41 differ greatly and is very low for the cost of the sanitation and plumbing system.

In Figure 190 is shown, that 33 respondents gave a value for all system in total. This value gives not the cost for all three system necessarily, what causes a great variation of the given values between 750 € and

150,000 €. But it also can be seen that the median value is 15,000 € and 75% of the values are ≤ 38,000 €. Which of the systems are included in the value was asked in question 43 and the results are shown in Figure 191. According to Figure 191 61% of the values for the cost of all systems included all three systems. The costs for all three system vary between 750 € and 150,000 €

In Figure 63 is depicted, how often different types of building damages occurred. The most frequent damages are damages to the pavement (88%), damages to interior linings (86%), damages to the doors (83%) and damages to the windows (66%). More substantial damages like expansions or contractions of the wooden structure occurred far less frequently.

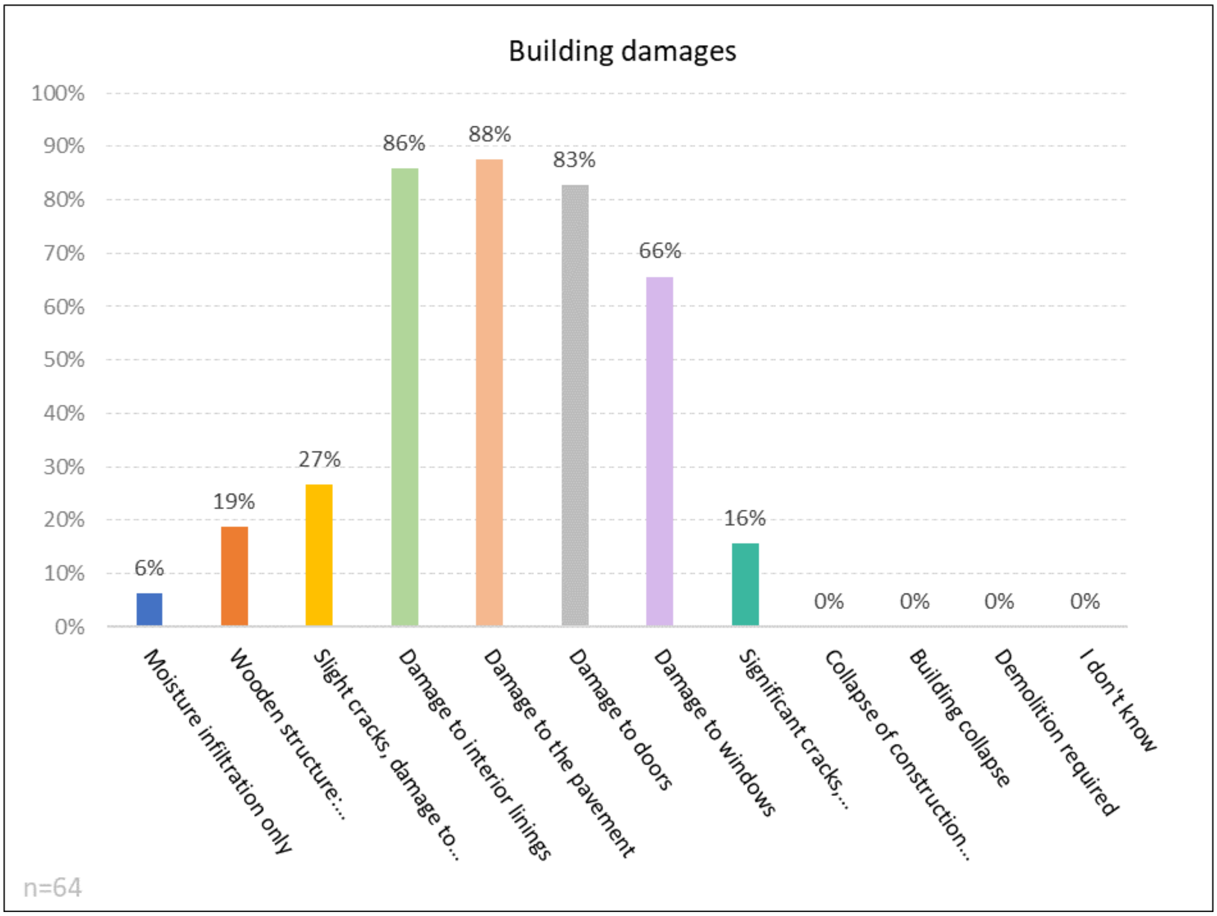



*Figure 63: Percentages of the types of damage which caused the flood at the homes of the participants, Germany (questionnaire part 2 residential, question 44).*

The costs related to the damages to the interior linings, the windows and the doors are shown in Figure 192. There were to options to give the costs for windows and doors in the questionnaire: The first was to give separate values for each (question 46 and 47, Figure 192 b) and c)) or one value for the total cost of both (question 48, Figure 192 d)). As the survey sample sizes of these three questions are low, the reliability of the results is limited. In Figure 64 can be seen, to what the participants attribute these building damages. The most frequently given answer is the water level (92%). Other causes lie between 13% and 39% and can be taken from Figure 64.

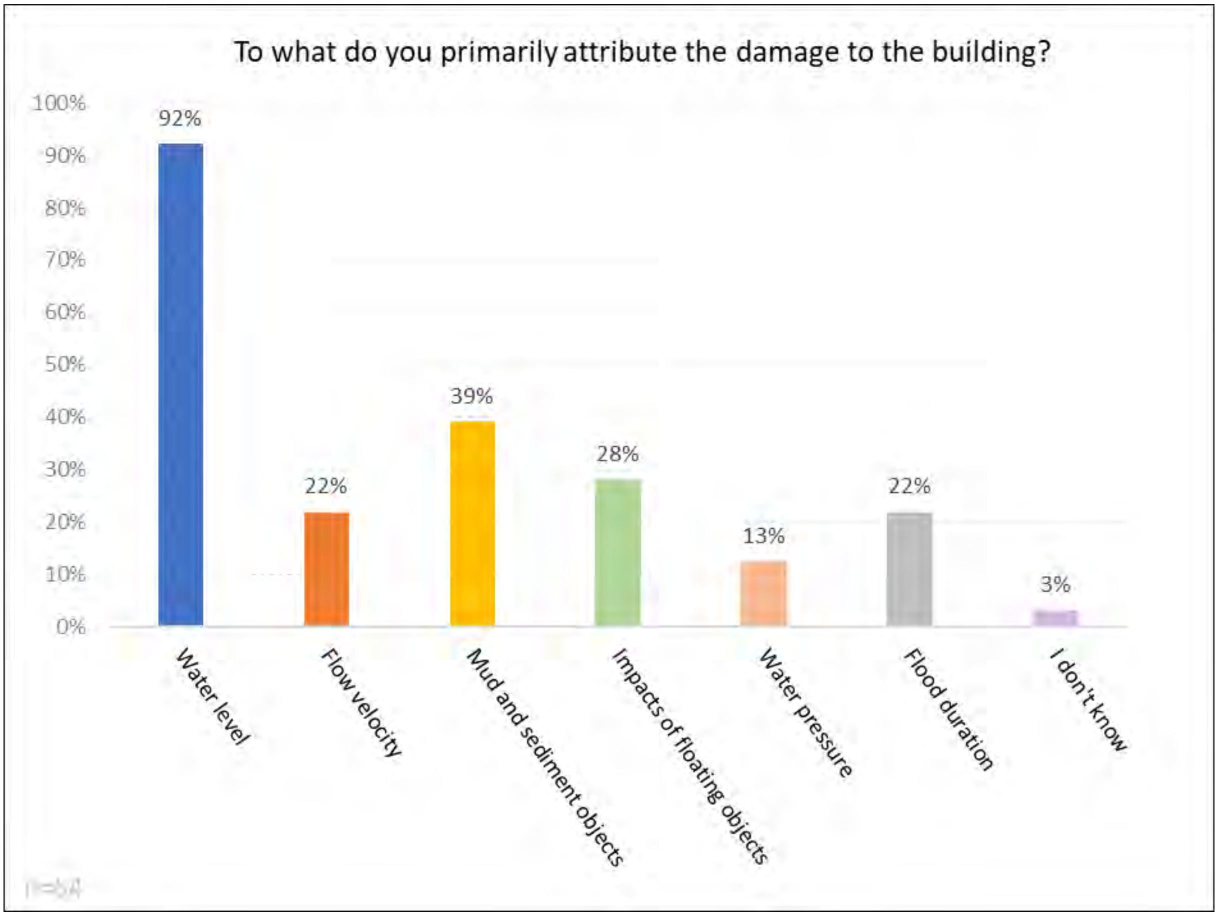



*Figure 64: Percentages of the cause to which the participants attribute the damages to their building, Germany (questionnaire part 2 residential, question 49).*

The statistical distribution of the total cost of all reparations to the building (including material and labour) is given in Figure 65. The minimum value is 2,500 € and the maximum value is 650,000 €. The median is 125,000 €. Compared to question 19 (Figure 57) it becomes clear, that the costs for the repair of the building is much higher than the costs for replacing household items. In fact, the median cost for the building damage (125,000 €) is five times the median cost for replacing the household items (25,000 €).

Figure 193 shows, on what the values for the total cost related to the building are based on. In contrast to the base of the values for the total cost related to the household (question 20, Figure 182) the percentages of invoices and expert estimates are much higher. Question 53 asks whether all damages are included in the value for all cost related to the building. As can be seen in Figure 194, only three answers were given to this question and hence the result has no validity. The validity of the results to question 54 are limited as well, as only eleven participants answered the question, whether the compensation is over or not (Figure 195).

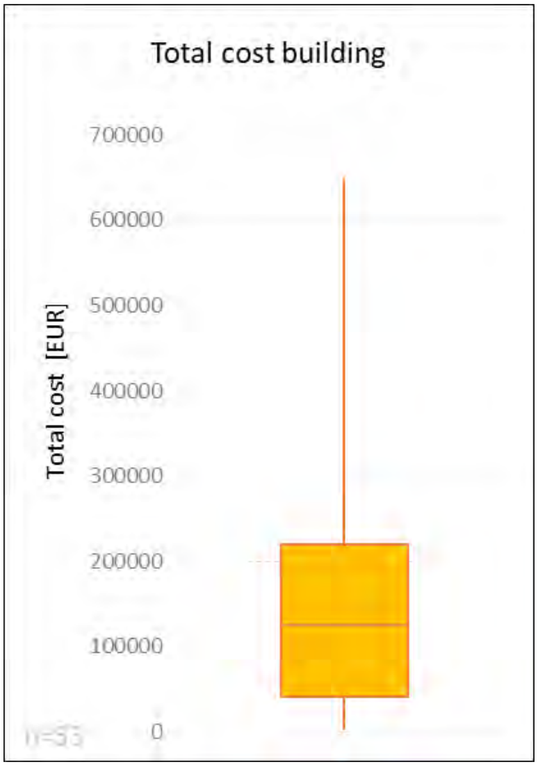



*Figure 65: Box plot of the total costs of all reparation work on and in the building (material and labor), Germany (questionnaire part 2 residential, question 50)*

In Figure 196 a) the hours for cleaning, participants reported to the insurance are shown. The range of the 17 given values is 24 hours to 1,400 hours. The median value is 375 hours. In Figure 196 b) the financial compensation, participants received from the insurance regarding the cleaning hours is shown. The compensation reached from 360 € to 14,000 € and the median value is 5,000 €. Regarding the reliability of the results, it must be taken into account, that the survey sample size of both questions is not very high.

In Figure 197 the boxplots for the cost for dehumidification (a)), decontamination (b)) and the total cost for cleaning (c)) are visible. As the survey sample sizes of the cost for decontamination (b)) and total cleaning cost (cc) are very small, the results of these question have no validity. The same applies to the results of the question, what is included in the total cleaning cost (question 60, Figure 198 The cost for dehumidification reach from 40 € to 14,000 €. The fact, that only 22 participants gave a value for the dehumidification cost does not mean, that other people didn't have or need dehumidification equipment, but because dehumidification equipment was so rare, not all people who needed some equipment get some.

As not all people were insured for such an event, just 34 participants could give a value for the amount of damage to the building which was approved by the insurance company (Figure 199). Within these 34 values there was a wide range of amounts approves by the insurance companies. It varies from 8,000 € to 650,000 €. The median is 134,500 €.

As can be seen in Figure 66, nearly half of the participants (45%) had to leave their house due to the damages of the flood. The survey team noticed that many people did not leave their house although heavily damaged and partially destroyed and they lived with many restrictions and under construction for a very long time. The statistical distribution of the number of days they left it is shown in Figure 67. The minimum is one day and the maximum 742 days. Some people were still not moved in again at the time of the interview.

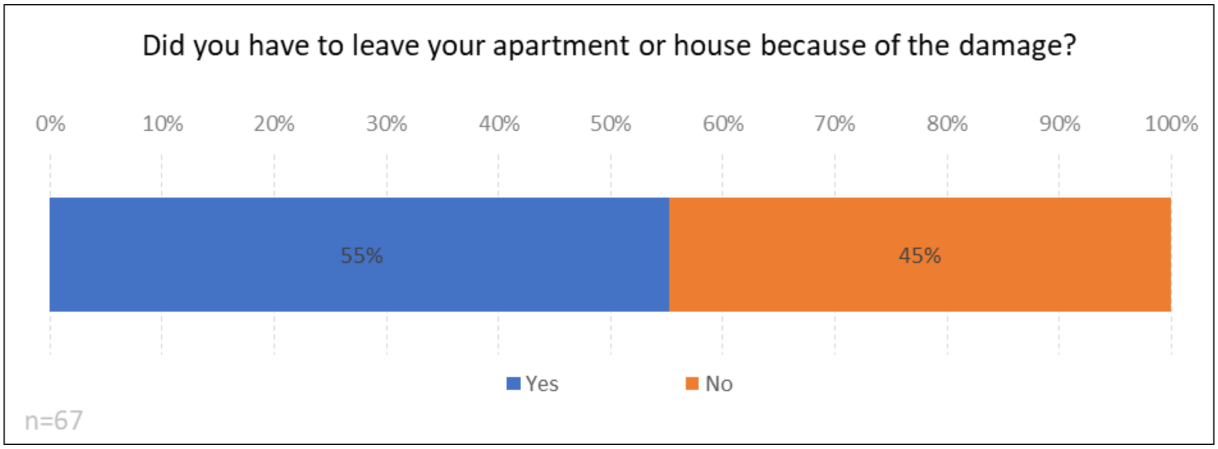



*Figure 66: Percentage of participants who had to leave the house because of the flood in July 2021, Germany (questionnaire part 2 residential, question 62).*

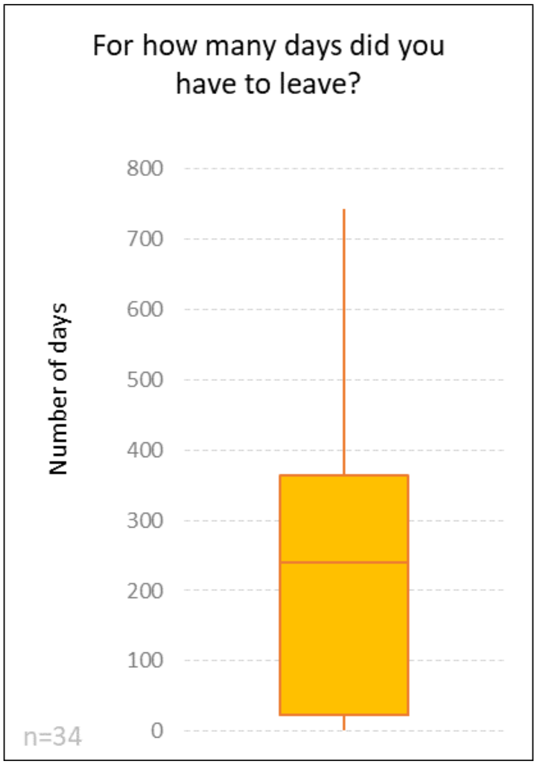



*Figure 67: Box plot of the number of days the participants had to leave their house because of the flood in July 2021, Germany (questionnaire part 2 residential, question 63).*

Like in question 24 for the household, question 64 asks to classify the completeness of the building on a scale between '0-completely restored and improved' resp. '1-completely restored' and '6-same state as immediately after the flood' (Figure 68). None of the participants classified their house as '6-same state as immediately after the flood'. Half of the respondents (50%) had their house completely restored (and improved) at the time of the interview (class 0 and 1), which was about 20-24 months after the flood event in July 2021. But even after this time 50% of the respondents still had not restored their house completely.

In Figure 69 the number of months that were needed to completely restore the building (case 0 and 1 of question 64, Figure 68) are depictured. According to this it took people between two and 24 months to restore their house completely. The median is eleven months.

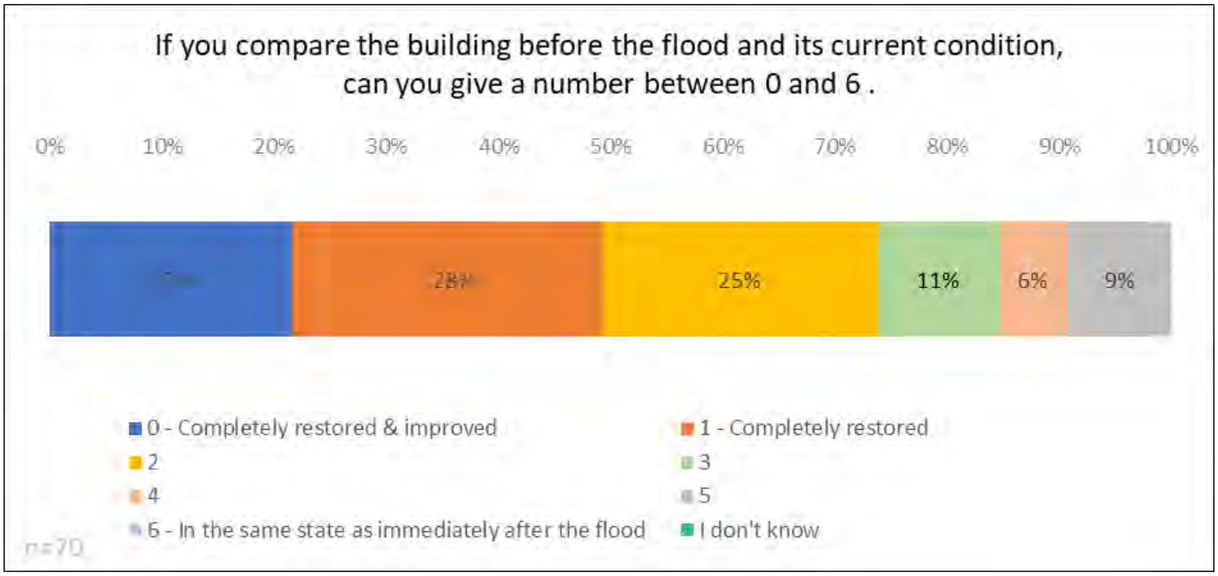



*Figure 68: Percentages of the assessment of the condition of the building, Germany (questionnaire part 2 residential, question 64).*

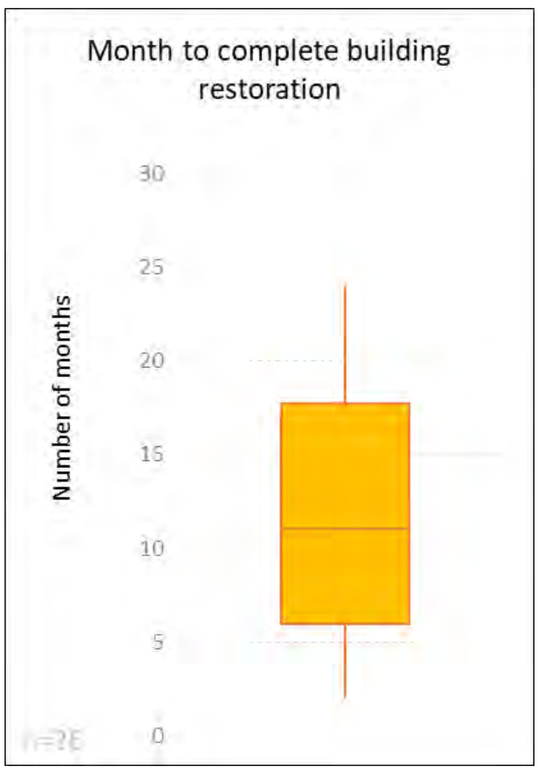



*Figure 69: Box plot of the number of months the participants needed to fully recover their building, Germany (questionnaire part 2 residential, question 65).*

Figure 70 shows different types of financial helps and the percentages of participants who received these. About two thirds of the participants received donations, official financial help, and money from the insurance. Other types of financial help participants received can be seen in Table 21.

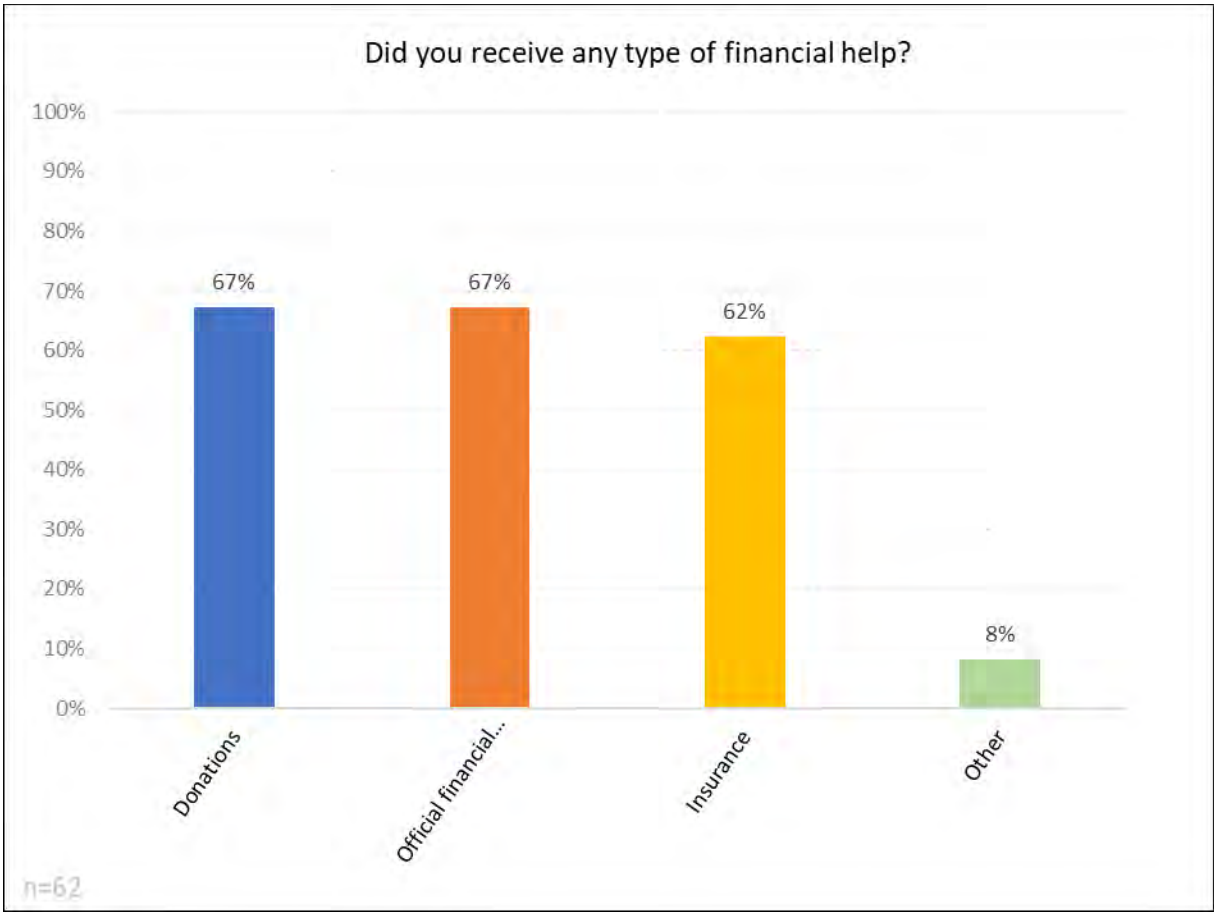



*Figure 70: Percentage of financial help type after the flood event, Germany (questionnaire part 2 residential, question 66).*

*Only 2 participants gave an answer to the question why they did not receive financial help (question 68), hence no graph was created. The first person ticked 'The damage is not covered by any (insurance) policy' and 'I don't know if I am entitled to compensation'. The second person ticked 'other', which was specified in question 69 (see Table 22).*

Figure 71 shows the box plots of the different types of financial help. It can be seen that participants received most money from insurance companies with an amount between 4,000 € and 800,000 € with a median value of 130,000 € (Figure 71 c)). The second most money people got from official financial help with amounts between 500 € and 125,000 € and a median value of 5,625 € (Figure 71 b)). The amount of money people got from donations lays between 100 € and 16,000 € with a median value of 2,500 €.

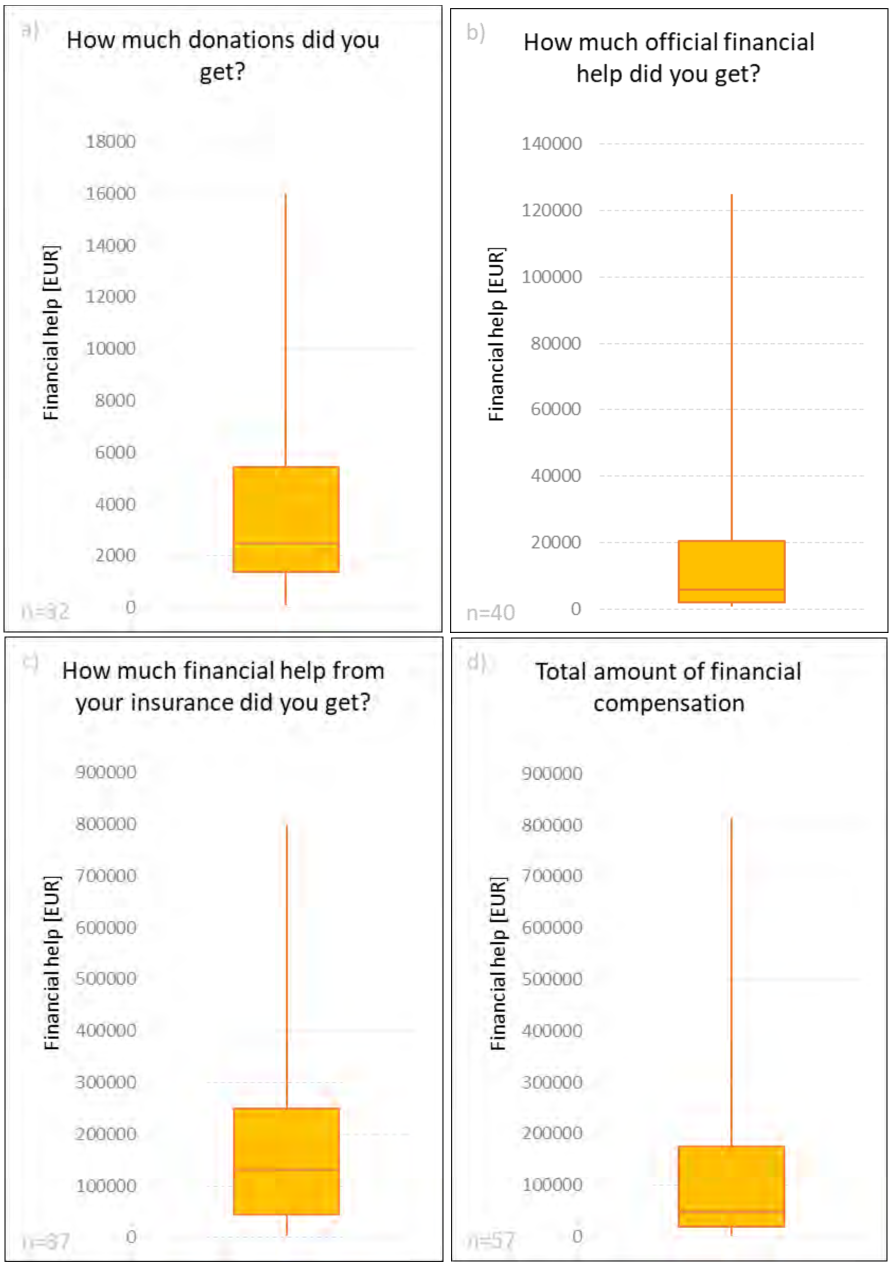



*Figure 71: Box plots amount of financial help a) amount of donations, b) amount of official financial help, c) amount of compensation by the insurance, d) total amount of financial compensation, Germany (questionnaire part 2 residential, question 70 – 73).*

Questions 74 and 75 were about the needs, participants still had at the time of the interview that had not yet been addressed and what in their opinion could have been done better in terms of information/support from government/own capabilities. The answers to both questions are listed in Table 23 and

Table 24.

As can be seen in Figure 72, 83% of the people did not receive any warning about the possibility of a flood. 14% received a warning only when their street was already flooded and only 3% received a warning before the flood occurred. Therefore, only twelve people could answer the question about the source of the flood warning (question 77, Figure 200). From these twelve people, most received a warning from neighbours (42%) or local authorities (33%). Each 17% received a warning via social media or other warning sources (see Table 25). Each 8% received a warning of severe weather via the weather service.


*Figure 72: Percentages of people who got a warning about the possibility of a flood or not and if yes, when, Germany (questionnaire part 2 residential, question 76).*

Question 79 asks about how many hours participants received the warning before the flood reached their house. For Germany only two participants answered. The answers were: 72 h and 24 h. In Figure 201 it can be seen, that 70% of the participants did not have time to implement precautionary measures after receiving the warning (question 80). As only twelve people received a warning, the survey sample size is very low for these results (n = 10). Hence, the results have a limited reliability. Question 81, which asks about how many hours after the warning people started applying emergency measures was answered by only one participant. The answer was: 1 h.

Figure 203 shows the results regarding to questions 82 (activities that people had undertaken or plan do undertake to be better informed of what to do in case of a flood: Figure 203 a)) and 83 (short term mitigation measures: Figure 203 b); long term mitigation measures: Figure 203 c)). Possible answers for the activities and mitigation measures were ‘in place during the event’, ‘after the event’ and ‘not planned/not possible'. It can be seen (Figure 203 a)), that 62% of the responding participants in Germany (n = 61) had in insurance in place during the event. It must be taken into account, that in Germany it must be differentiated between a 'normal insurance' and an 'elementary' insurance, which also additionally covers elementary damages, which means damages caused by nature like earthquakes, volcanic eruptions or floods. It is not clear, which type of insurance people, who answered this question with 'in place during the event', had. Another thing that can be seen in Figure 203 a) that only 7% of the responding participants searched for individual flood protection and only 11% consulted existing hazard maps before the event. Even after the event more than half of the participants did not do these activities. From Figure 203 b) can be taken, that 40% already had pumps in place during the event. But in the interviews many people reported to the interview team, that their pumps were stored in the basement and were flooded and thus broke down and were not usable in the event. From Figure 203 b) and c) it is noteworthy, that even (in six month) after the event most participants did not undertake some activities or implement mitigation measures. During the interviews it became clear to the survey team, that people did have too many things regarding to the reconstruction on their minds in at least six months after the flood and much longer in many cases.

As is shown in Figure 41, 63% of the respondents did not implement certain mitigation measures after the event because of a lack of financial means. Another 19% stated that they were overwhelmed by the even, they did not know what to do or had a lack of information. Each 13% stated, that the work would not be covered by an insurance, an event like this should not happen again because it was an extreme event, and it should not happen again because it was due to mismanagement of a dam/human error. 6% gave missing space as a reason for not implementing certain measures. It must be taken into account, that the survey sample size in only n = 16, because the survey team did not ask this question in every interview, because many people were very emotionally burdened.

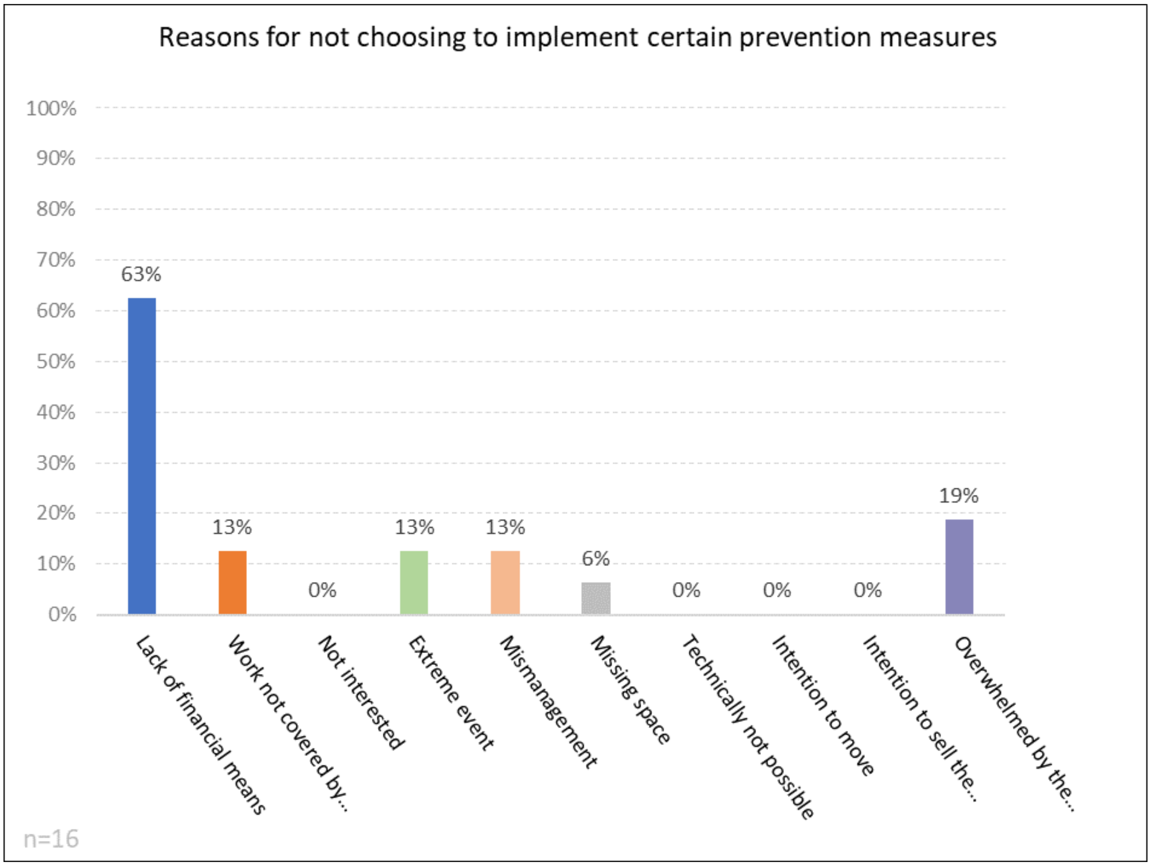



*Figure 73: Percentages of reasons, participants did not choose to implement certain prevention measures following the event, Germany (questionnaire part 2 residential, question 84).*

Regarding question 85 78% of the respondents (n = 67) never have been affected by a flood before (see Figure 74). 19% were affected once before and 3% twice. To achieve consistency in the data, the survey team defined ‘’to be affected by a flood event’ as having any kind of damage due to a flood event All participants told the survey team, that they never experienced a flood this heavy before. Participants who had been affected by a flood before were asked when the las time was (question 86). The answers can be seen in a timeline in Figure 75.


*Figure 74: Percentages of participants who were affected once or several times by a flood before the event in July 2021, Germany (questionnaire part 2 residential, question 85).*

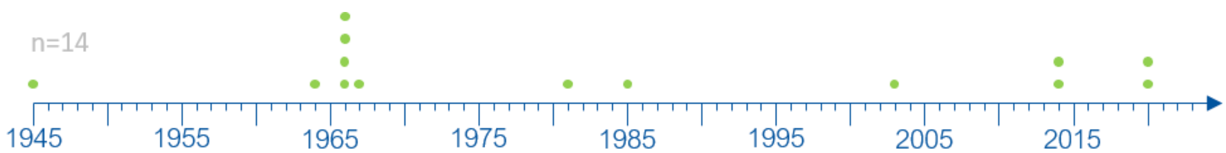



*Figure 75: Year of the last flood, Germany (questionnaire part 2 residential, question 86).*

## 4.3 Netherlands

### 4.3.1 Survey statistics

In the Netherlands 306 doors have been rang. Most of them have been in the municipality of Valkenburg. A small portion has been conducted in the municipality of Gulpen-Wittem. The participation rate can be seen in Figure 76. In total 79% of the rang doors either didn't open or didn't want to participate. During the survey, it was not clear if people were not at home or that the building was abandoned. There were a few commercial buildings that showed clear signs of closure. The exact number of abandoned buildings has not been registered during the survey.

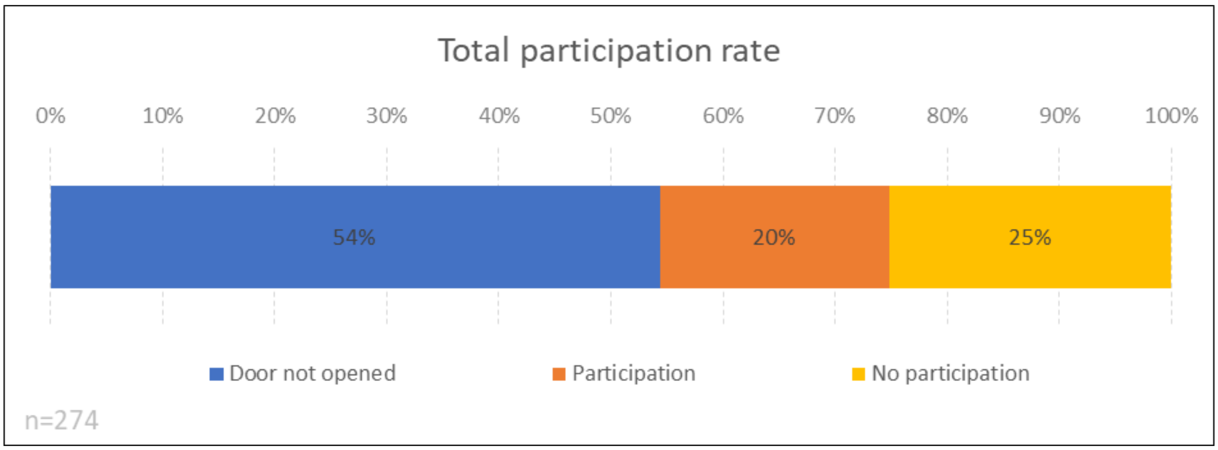



*Figure 76: Total participation rate, Netherlands.*

Besides the participation rate the reason for no participation was registered (Figure 77). A small amount of the questioned people mentioned they recently moved into the building. Furthermore, being traumatized by the event and not interested ended up equally represented during the survey.

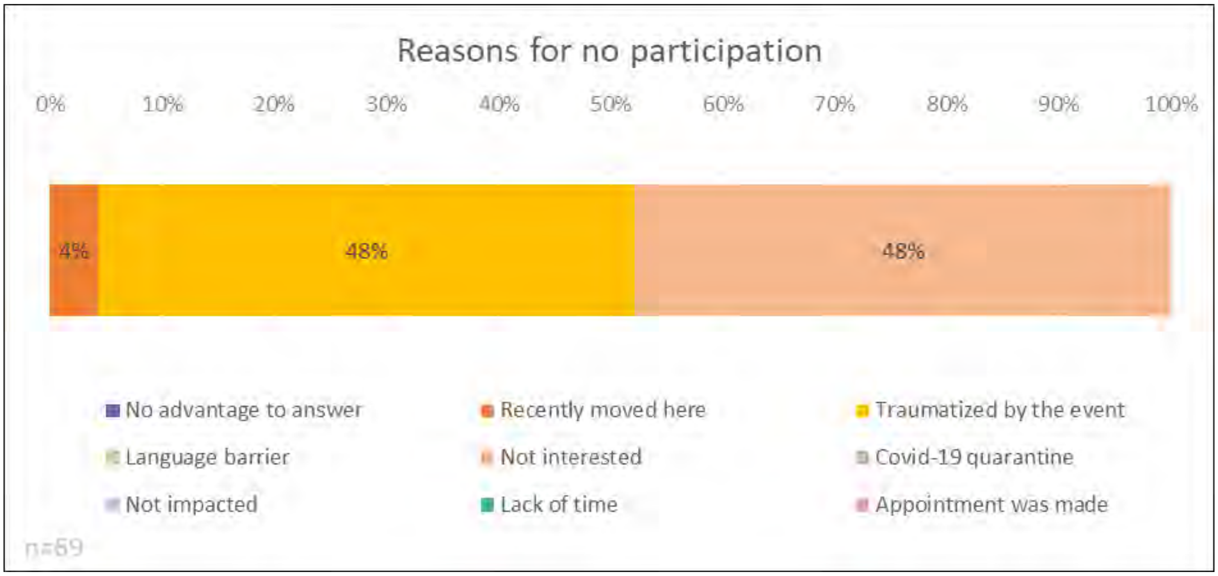



*Figure 77: Reasons for no participation, Netherlands.*

In the Netherlands, the main source of interviews was spontaneous interviews by ringing doorbells in the affected area. A small percentage of the interviews were based on appointments either made at the door or made based on promoting the survey in personal circles.

### 4.3.2 Part 1

In part 1 of the questionnaire, the participants are asked about personal information. For all questions in this part of the questionnaire, 72 answers have been given originating either from residents or owners/employees of commercial buildings in the Netherlands. The majority of the interviews have been conducted in the municipality of Valkenburg, and a small portion have been conducted in the municipality of Gulpen-Wittem. Both municipalities were affected by the flood of July 2021 caused by the Geul river, see Figure 78 for the percentages of surveys conducted in each municipality.

More than half, 64%, of the participants had an educational level with a Bachelor's degree or higher. The remaining part consists of an educational level with a High school degree and only a small portion finishing Elementary school. The figures showing the education level can be seen in Figure 79.

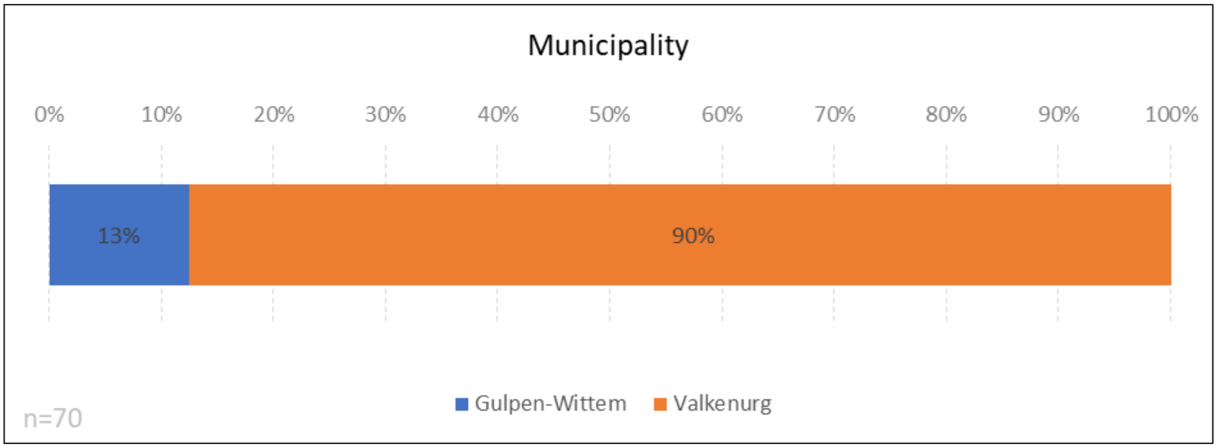



*Figure 78 : Percentages of municipalities the participants live in, Netherlands (questionnaire part 1, question 2).*

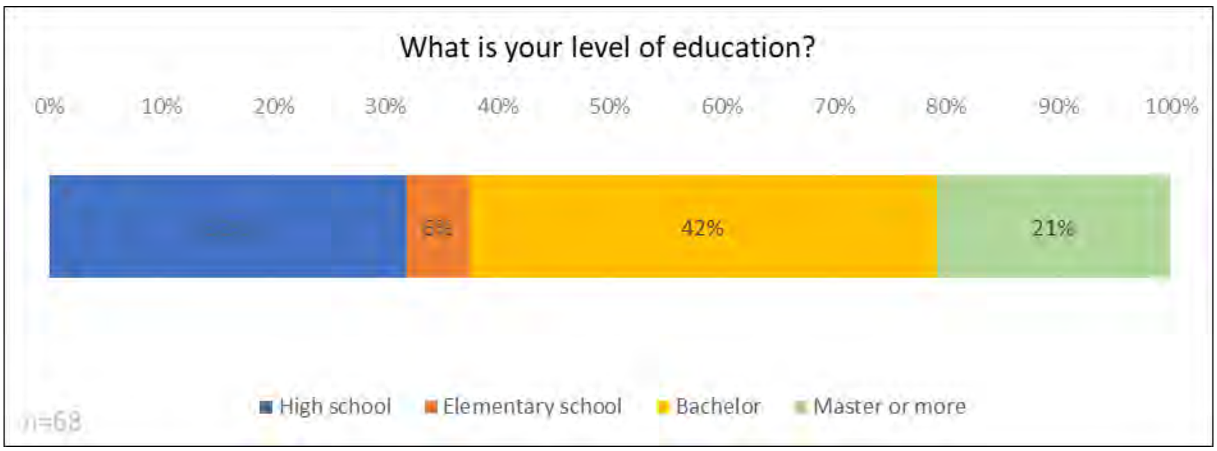



*Figure 79: Percentages of the participants level of education, Netherlands (questionnaire part 1, question 10).*

The current socio-professional status of the participants was also asked, an overview of the results of the Dutch surveys can be found in Figure 80. It can be noted from this graph that almost a third of the participants are retired and that more than half of the participants are either employed or self-employed. About 5% of the participants were unemployed. It needs to be noted that the majority of the interviews were conducted during working days between 9 AM and 5 PM. A result of this period of conducting the surveys could be that the socio-professional categories are not completely representative of the area. The same accounts for the educational level of the participants.

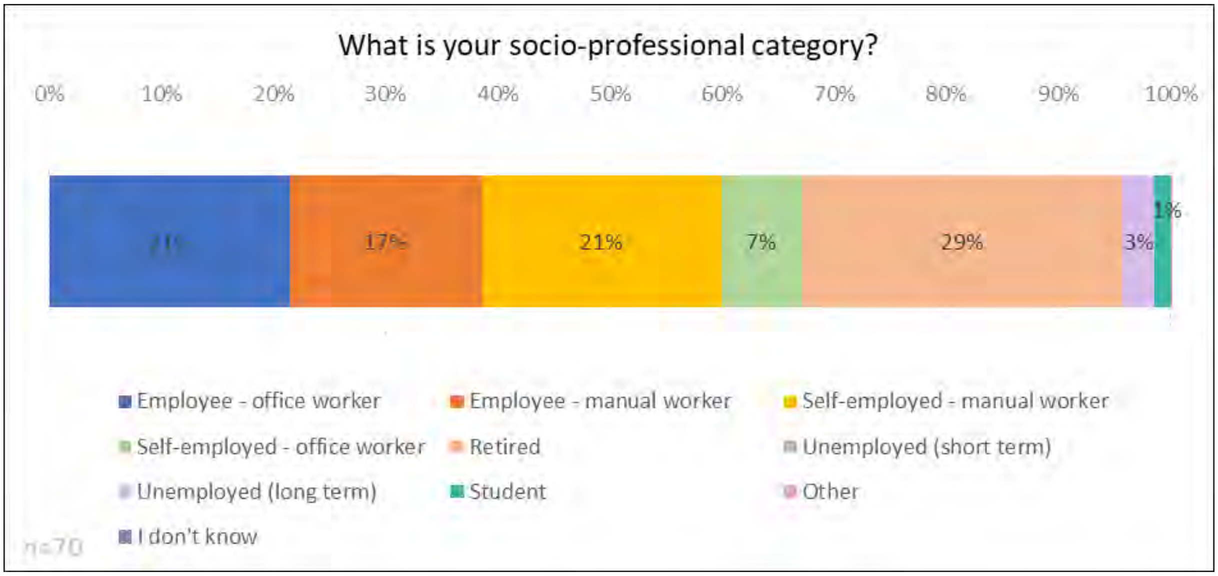



*Figure 80: Percentages of the participants socio-professional category, Netherlands (questionnaire part 1, question 12).*

The last question regarding being informed about the progress of the study was answered by the majored of the participants with a 'Yes, I want to be informed of the progress". This shows that a high number of the participants were interested in the outcomes of the research. Email addresses or phone numbers were collected of the participants who wanted to be kept informed.

### 4.3.3 Part 2 (Residential sector)

Part 2 of the questionnaire consisted of questions regarding the effect of the July 2021 flood on the building of the participants. The duration of the questionnaire is calculated from the start and end time, resulting in a median interview duration of 55 minutes. It can be noted in Figure 207, that according to the data the questionnaires took between 5 and 85 minutes. Considering the large number of questions asked during the survey, the questionnaire with a duration of 5 minutes contains probably a mistake in either the start or the end time. The durations differed during the surveys due to multiple factors. One of the factors is how much participants still know about the event and the accompanied damage. Another factor is how direct the interview is the elaboration of answers that were given, which could be very brief and straight to the point but sometimes also brought up many stories.

No interviews were conducted during online media or phone conversations. The preference of the study was to interview types conducted directly in the field. This would make sure the questions and answers were sufficiently understood.

In the Netherlands, none of the participants experienced water depth on the first floor. Therefore in Figure 81 water depths only up to the ground floor can be found, while this was asked up to the first floor. Comparing the water depth at the front door with the water depth at the most flooded point gives an interesting view of the difference in water depths against the building of the participants. For the Netherlands, these differences are caused by two separate factors. In the hilly areas of the South of Limburg, many gardens are located lower than the front door, resulting in a difference in water depths.

The front door is in many cases located at a higher located road and the backside of the building is occasionally even lowered until basement level. The second factor for this difference is that the front door entrance is in the surveyed location elevation by either stairs or a levee, possibly to keep out water during flood and rainfall events. The water depth of the basement is high, whereas during the survey a water depth of 2 meters is indicated as a fully flooded basement. The figure shows that the lower quartile up to the upper quartile are within 1.5 meters up to the maximum of 2 meters. There is a survey that shows a higher water depth, which probably means it belongs to the group of completely flooded basements. The water depths at the ground floor are all relatively low, showing that the water depths are a bit lower than the water depths at the front door. This means that small inundations on the ground floor are when present combined with completely flooded basements. The use of the basement in this case can have a large influence on the damage caused to the house.

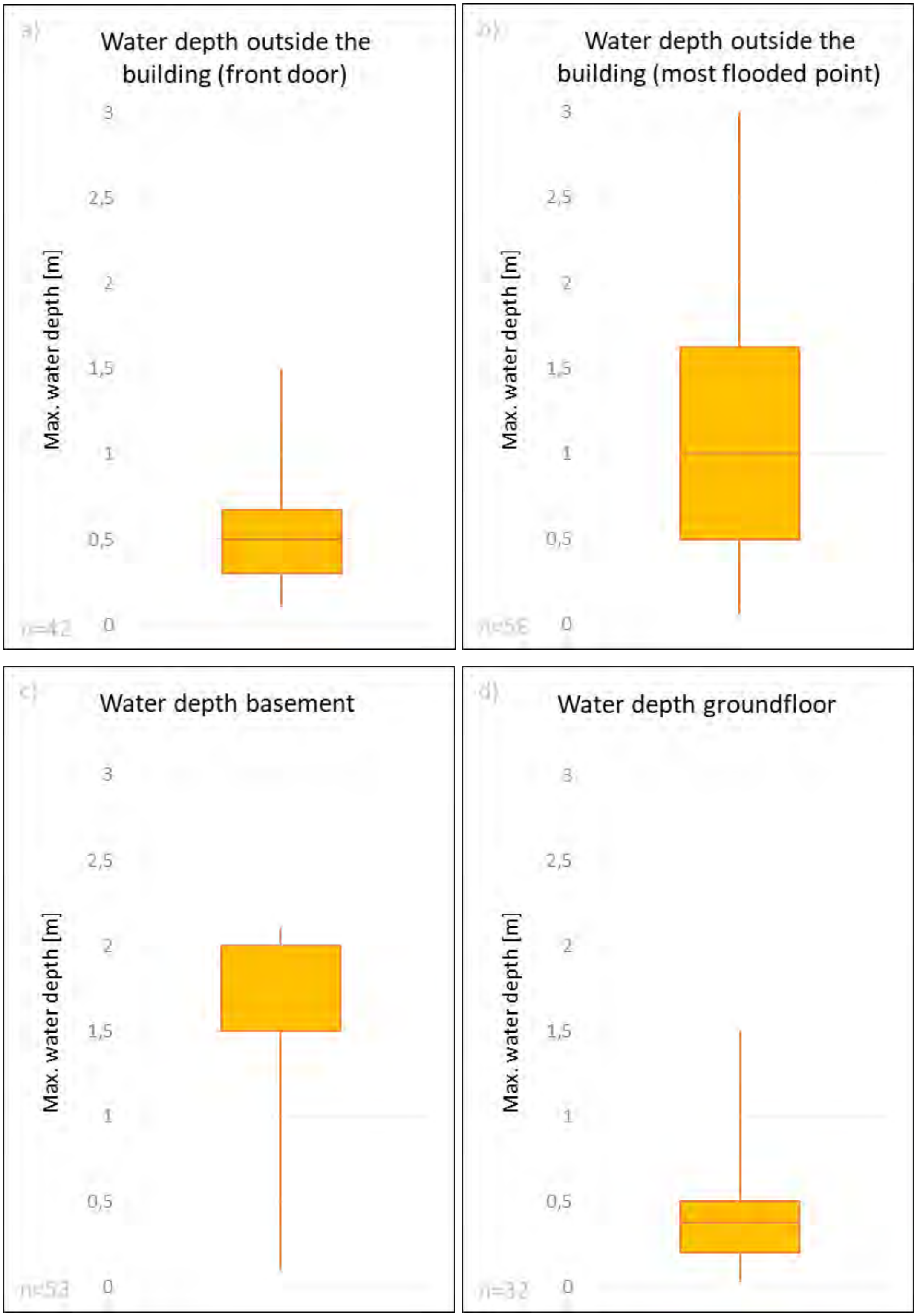



*Figure 81: Box plot of the maximum water depth during the flood a) outside the building (front door), b) in the basement c) on the ground floor, Netherlands (questionnaire part 2 residential, question 3).*

What is noticeable from Figure 209 is that a very high percentage of the participants own the building during the flood event, whereas a small percentage rented the building. Many of the participants attributed the flooding to either runoff or overflow from a watercourse or a combination of the two. Most participants from Gulpen-Wittem mentioned flooding of their homes due to sewage and/or groundwater. Also, the mentioning of the failure of a dike or dam is present. During the interviews, participants mentioned the opening of weirs or rainwater buffers as the cause of the severity of the flood.

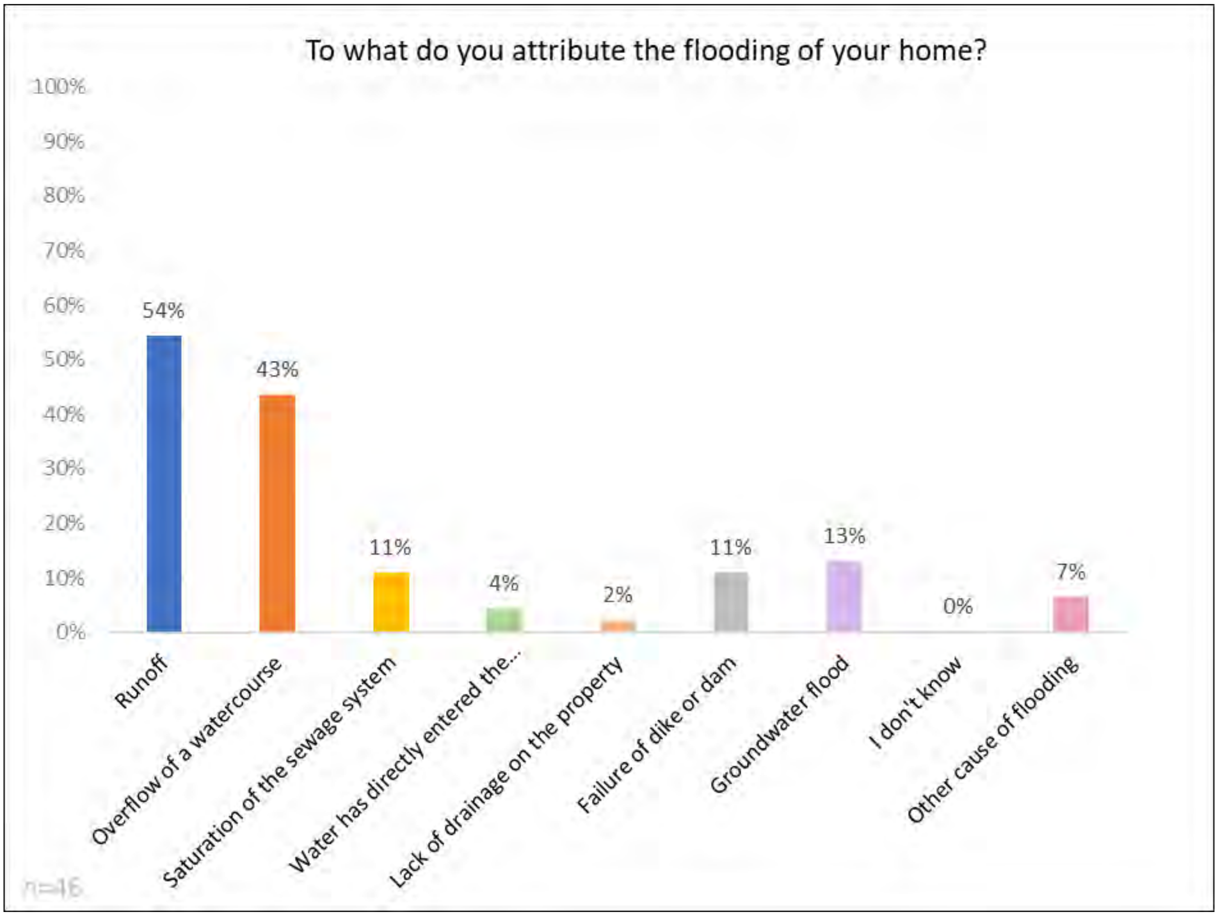



*Figure 82:Percentages of to what the participants attribute the flooding of their home, Netherlands (questionnaire part 2 residential, question 5).*

The next questions focus on the individual estimation of the magnitude of the discharge/flow velocity in terms of 5 categories. From Figure 83 it can be observed that the majority answered that they should have made an effort to stay upright followed by a group responding they could have easily stood in the water and a group that mentioned they would have been swept away. A few participants responded the water was too deep to stand outside.

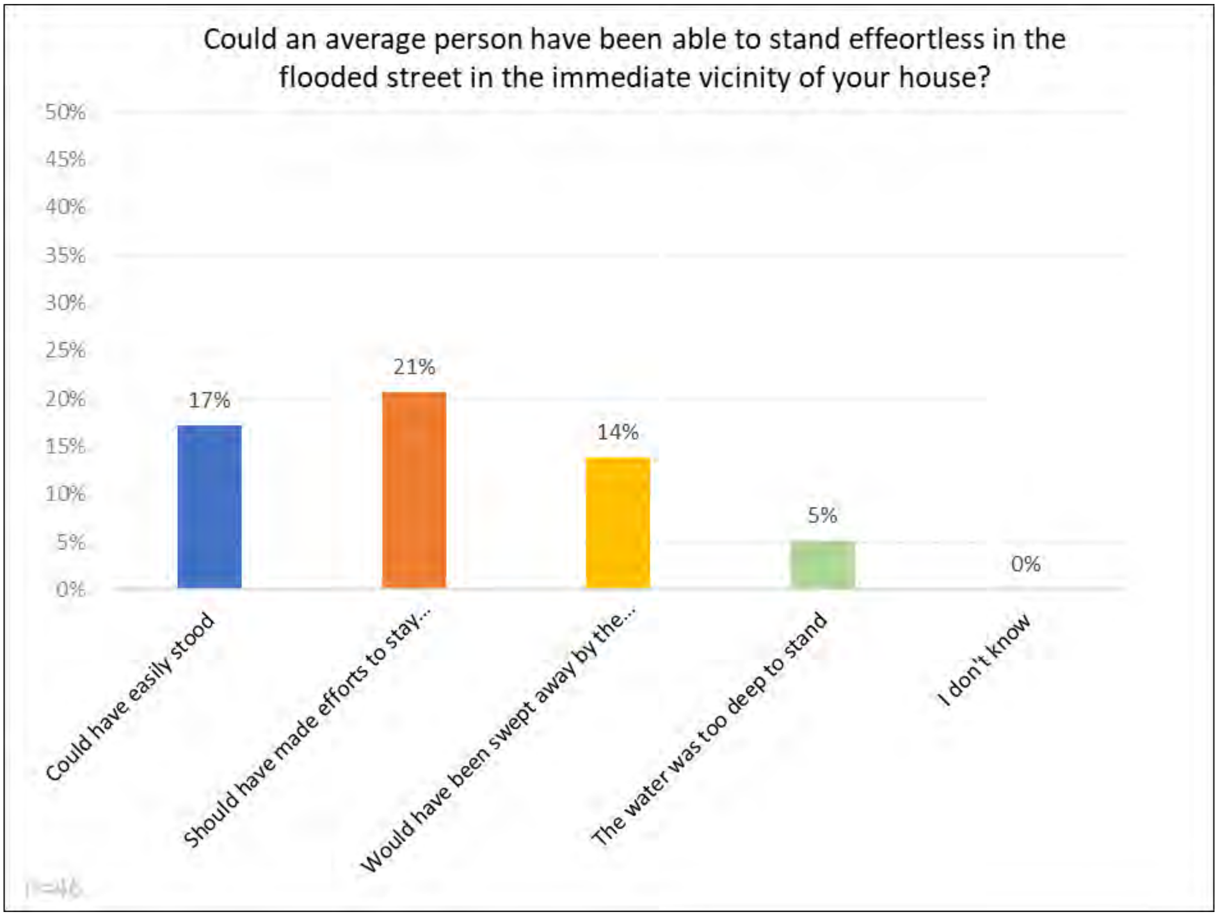



*Figure 83: Percentages of subjective estimates of the magnitude of the discharge/velocity of the participants, Netherlands (questionnaire part 2 residential, question 7).*

The front door elevation response from the participants can be seen in Figure 210. The majority of the buildings in the surveyed area of the Netherlands have an elevated front door by either stairs or a levee between 0.6 meters and 1 meter. This is much higher than the average building in the low-lying part of the Netherlands. This indicates that during the build of the houses it is taken into account to elevate the house to be protected from water entering via the front door.

The surveyed buildings in the Netherlands suffered for 90% of the cases damage to the basement and 66% of the cases damage to the ground floor, see Figure 84. A small percentage also experienced damage to the 1st floor; this damage is caused by moisture in the walls induced by capillary rise. The follow-up question regarding the finishing of the basement shows that 67% of the basements are built in such a way that it is liveable and for the first floor all were finished, see Figure 211 and Figure 85.

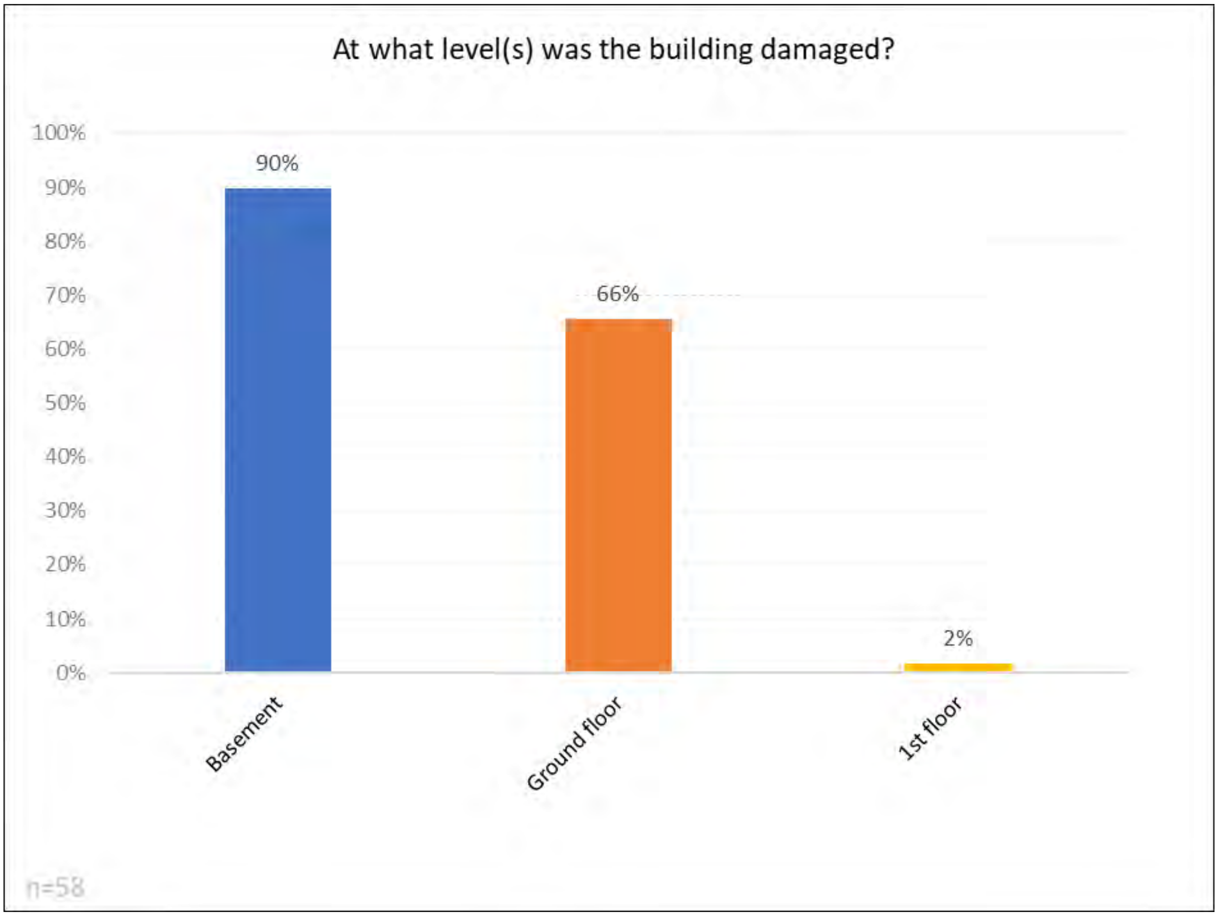



*Figure 84: Percentages of the levels, on which the homes of the participants are damaged, Netherlands (questionnaire part 2 residential, question 9).*

From all answers of the participants on the transported materials, mud was mentioned the most followed by sand/stone and garbage. Vegetation, rubble, and large objects are mentioned in a lesser degree, as can be seen in the overview of Figure 85. All participants mentioned at least one of the materials to be deposited in their building caused by the flood. The size of the materials found near the building were variating, but the majority was smaller than 1 meter in size, See Figure 86 for the variation in the mentioned material sizes.

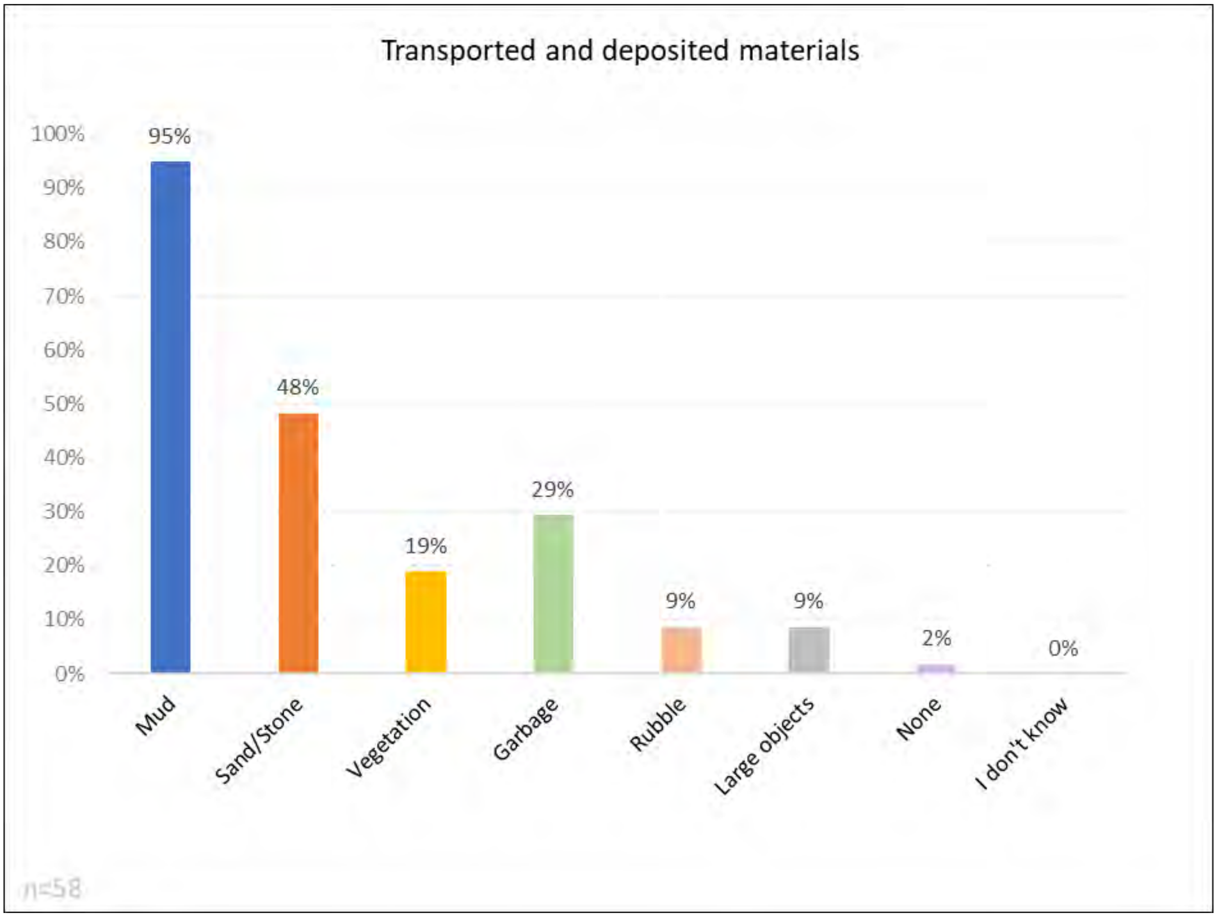



*Figure 85: Percentages of what materials were transported or deposited in the buildings or had direct contact with them, Netherlands (questionnaire part 2 residential, question 11).*

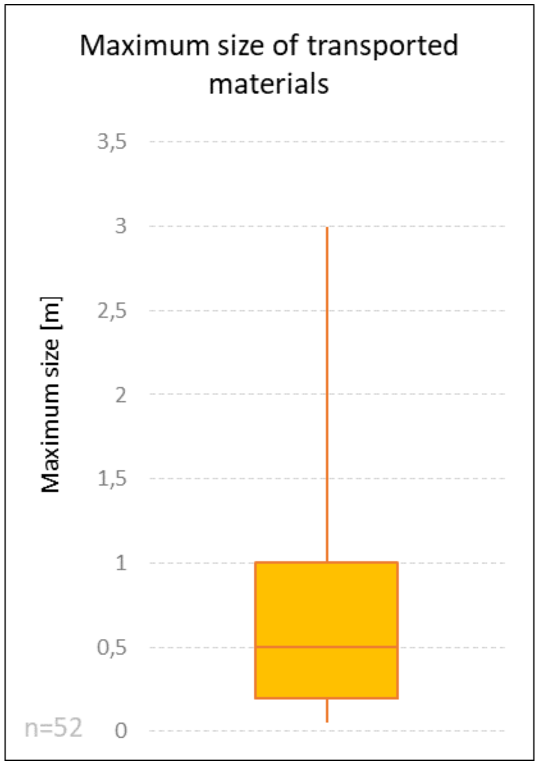



*Figure 86: Box plot of the maximum estimated size (length) of the transported/deposited materials in question 11, Netherlands (questionnaire part 2 residential, question 12).*

To give a second estimation on how strong the flow of water was in the vicinity of the building, this was asked again but now in terms of calm to torrential flow, ranging in numbers from 1 to 6. The response to this question shows in Figure 87 that the majority experienced the flow as medium flow up to torrential flow. A small portion of the participants experienced the flow as calm flow.

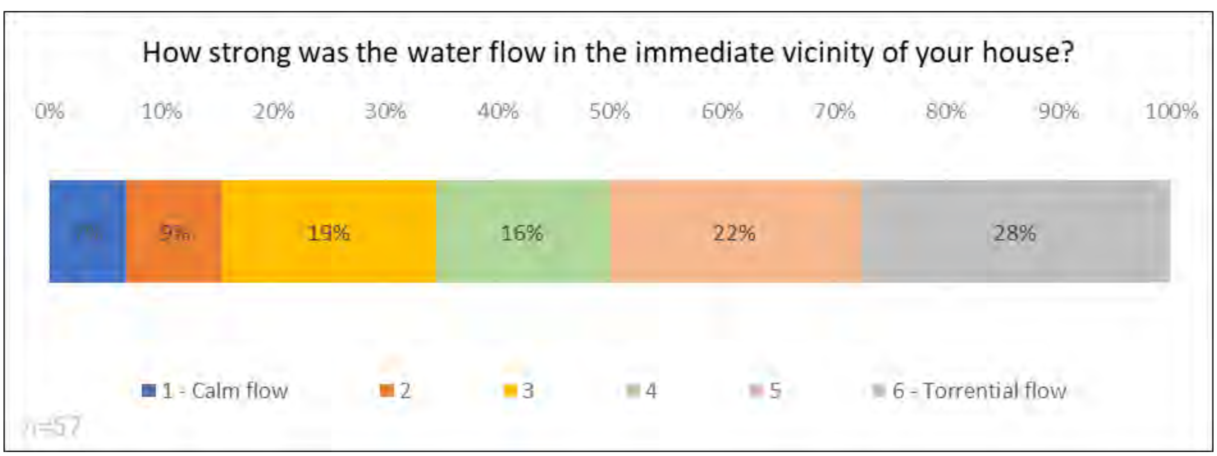



*Figure 87: Percentages of the estimation of the strength of the water flow in the direct vicinities of the participants homes, Netherlands (questionnaire part 2 residential, question 13).*

Many of the participants mentioned contamination by either chemicals, sewage, or hydrocarbons. Of the response on sewage contaminations, most participants mentioned that the water entering the building was already contaminated with sewer faeces and was not contaminated inside the house by mixing with sewer overflow. It is also worth noting about Figure 88 that a large part of the participants did not experience any contamination due to the flood in their house.

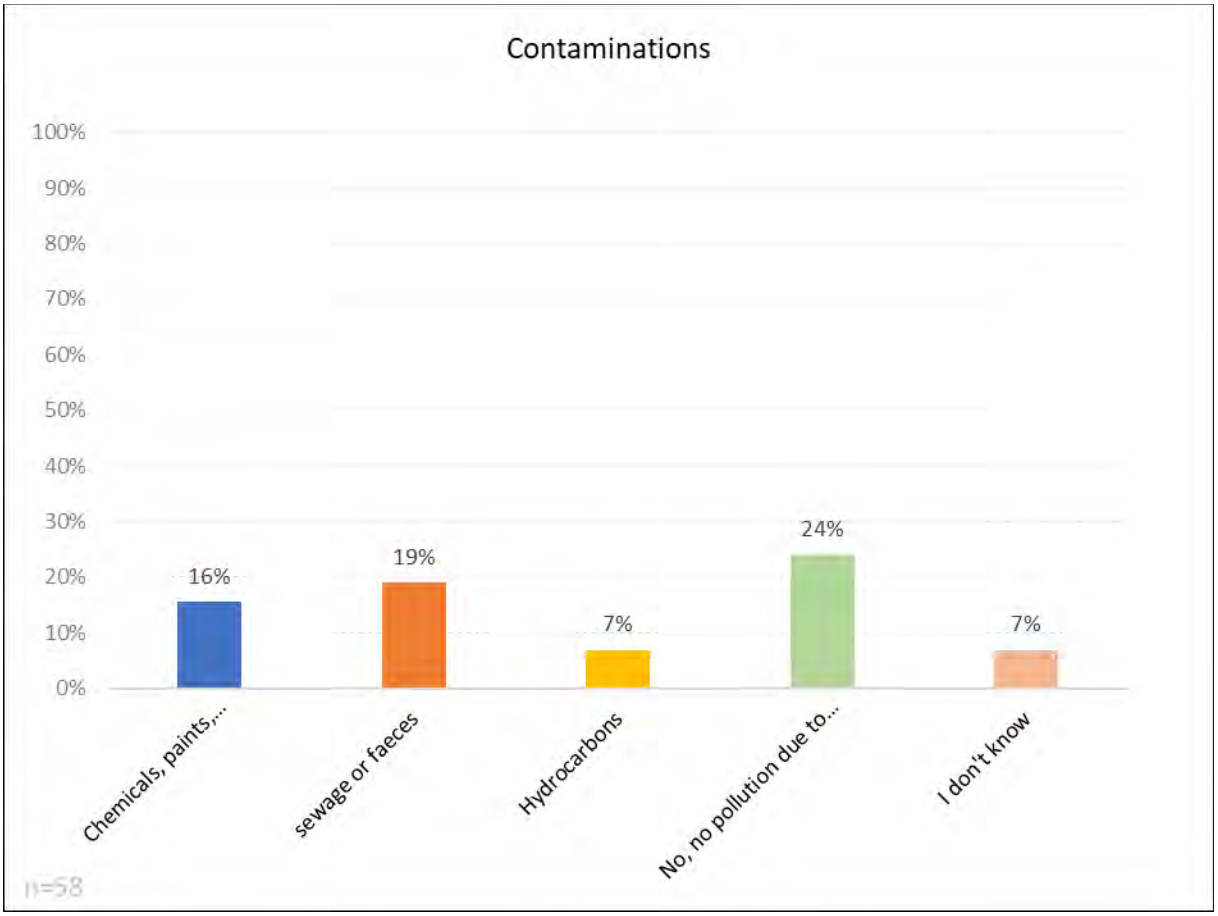



*Figure 88: Percentages of the records of the observed contaminants in the homes of the participants, Netherlands (questionnaire part 2 residential, question 14).*

The median ground floor area of the questioned buildings lies around 75 m$^2$, with most variating between 50 and 100 m$^2$. In Figure 213 a list of the household items that needed replacement after the flood are listed according to the survey results. Noticeable is the high percentage of damaged boilers (37%), indicating that many households placed the boilers at locations that were flooded during the event. The high number of basements that were flooded can be traced back to the type of flooded household items that are mainly stored in basements/storage rooms like electrical appliances, tools and leisure items. Also, a high percentage of kitchen/bathroom-related objects were damaged like fridges and washing machines. Smaller and lighter items have a lower percentage, probably because these could have been moved more easily when signs of the flood were noticed.

Concerning impacted vehicles like cars and motorcycles, around 26% of the participants had cars that were damaged by the flood. For damage to motorcycles, this was only 10% of the cases. Most participants were able to move their car during the flood to higher grounds. It needs to be noted that not all participants owned cars or motorcycles and that relatively more cars than motorcycles were owned.

Regarding actual damage to the household contents a statistical distribution can be found in Figure 89. The household damage ranges between 0 and 100.000 euros with the median lying at 20.000 euros. This shows a wide range of damage concerning household damage. Typical factors that influenced the height of this damage number were affected kitchens and appliances but also the way of use for the basement. The basement was in the south of the Netherlands in many cases used as a liveable area, and therefore contained household items, bedrooms, kitchens, and bathrooms.

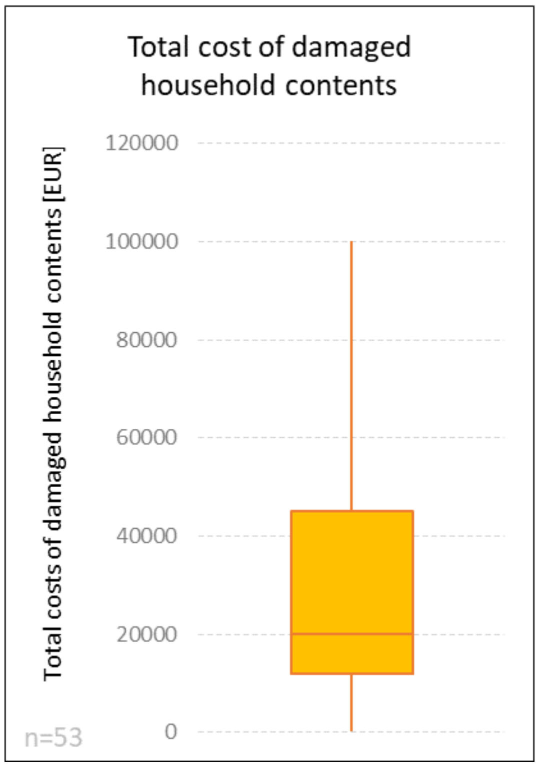



*Figure 89: Box plot of the total costs of damaged household contents of the participants, Netherlands (questionnaire part 2 residential, question 19).*

Typical for this event that was noticed during the survey was that many participants knew a lot about the occurred damage in a high level of detail. A reason for this was that the insurance asked for a lot of information about the damaged products, which resulted in a good overview for the participant. A few participants had advisors or family members to take care of the damage part. On what source the household damage numbers are based can be seen in Figure 215. From Figure 216 can be seen that two years after the event 95% of the cases were complete and all damaged goods were mapped.

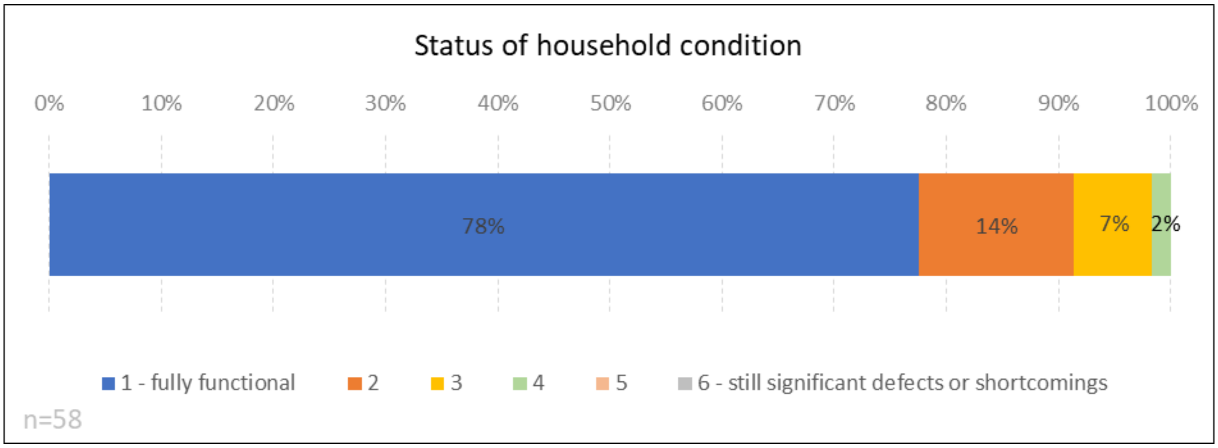



*Figure 90 : Percentages of people who ranked the status of their households condition in the different categories, Netherlands (questionnaire part 2 residential, question 24).*

The status of the household content was still not completely back to a fully repaired state, as can be seen in Figure 79. All participants mentioned a recovery time of less than 2 years and 75% of the participants mentioned a recovery period of less than 6 months. It can be noted that there is a difference in the feeling of being recovered while the state is not back to fully functional.

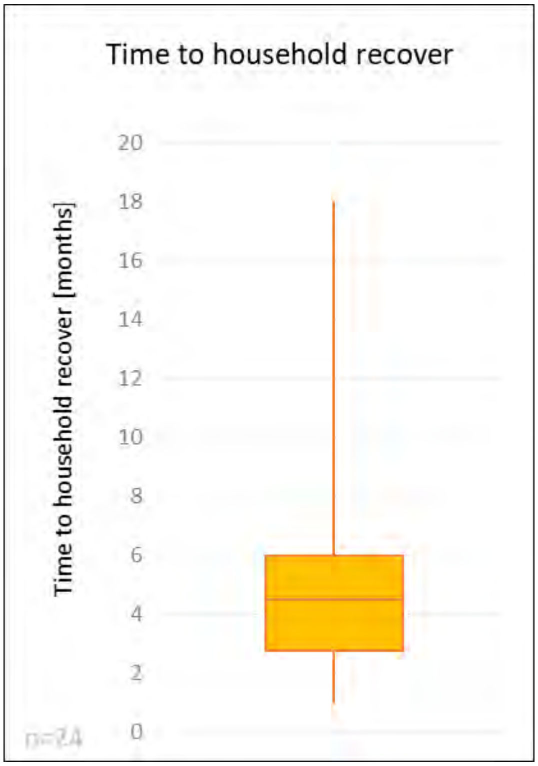



*Figure 91: Box plot of the number of months the household of the participants needed to fully recover, Netherlands (questionnaire part 2 residential, question 25).*

There is a high number of buildings with the type “detached” and “semi-detached” among the participants, see Figure 219. Detached and semi-detached buildings have a higher explosion of walls during a flood. Also, the amount of building levels is high, with around 97% of the buildings having more than 3 floor levels. For this question basements and attics were included within the floor count.

The south of Limburg is built on a large base from natural stone (marlstone) and clay masonry. The older buildings were mainly built from marlstone as a base, see Figure 220. This type of stone is commonly found in the many marlstone caves in the south of Limburg. This type of natural stone is less protected against water because of the large number of open pores. This results in moisture intrusion that takes a while to exit, giving a lot of people moisture problems in the basements. The ground and upper floors are mainly built from clay masonry, as can be seen in Figure 220.

As mentioned earlier commenting on the household damages, the basements in the flooded area were used as liveable areas by many participants as can be seen in the room use in Figure 221.Many participants used the basements as laundry/drying rooms, storage space and as garages for bikes or cars. The high percentage of basements being utilized as technical installation rooms also indicates their susceptibility to flooding, particularly concerning electrical and heating systems.

In Figure 92 and Figure 93 it can be seen that 75% of the buildings from the questionnaire were built before the year 1970 and 23% were built even before 1945. This shows that there is a relatively low percentage of recently built buildings. This explains why there is such a high percentage of buildings using gas heating, see Figure 222, while newly built buildings are transferring to other types of heating sources.

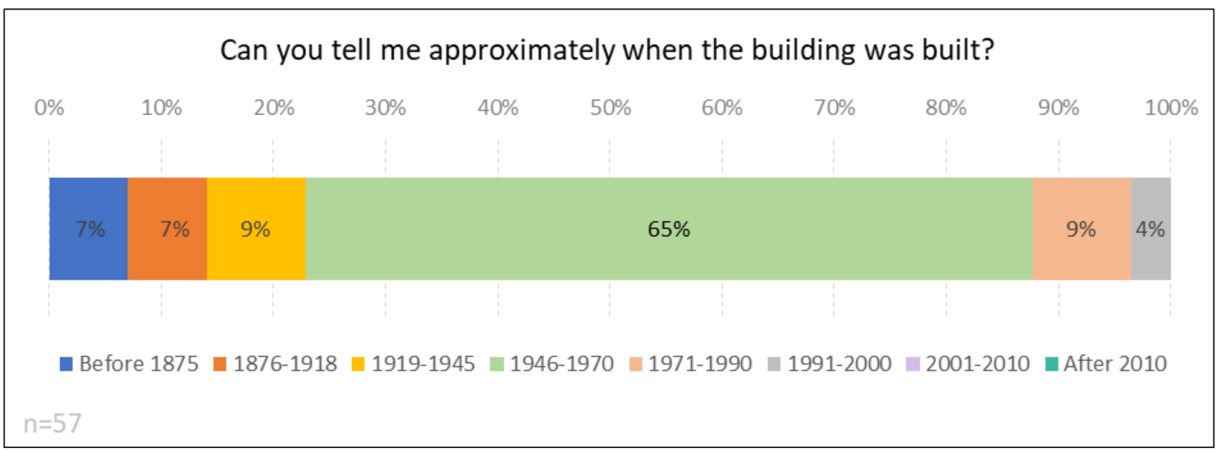



*Figure 92: Building period of the buildings the participants live in, Netherlands (questionnaire part 2 residential, question 33).*

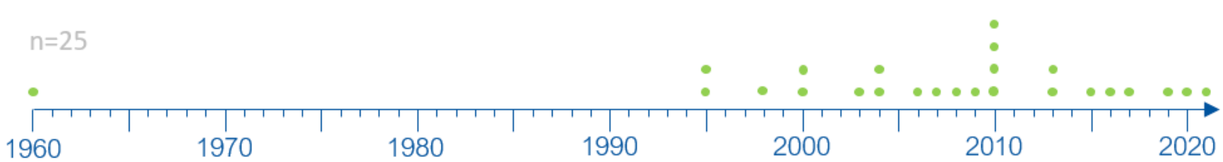



*Figure 93 : Last major renovations of the buildings the participants live in, Netherlands (questionnaire part 2 residential, question 34).*

Given that a house is located in a flood-prone area, placing the heating system in the basement is a risky choice. It's important to note that many individuals who were affected by this recent flood may not have previously encountered such flooding, especially those residing outside regions like Valkenburg, which experience more frequent floods. A large part, 24%, placed the heating system in the attic as can be seen in Figure 94, where 53% have their heating system located in the basement.

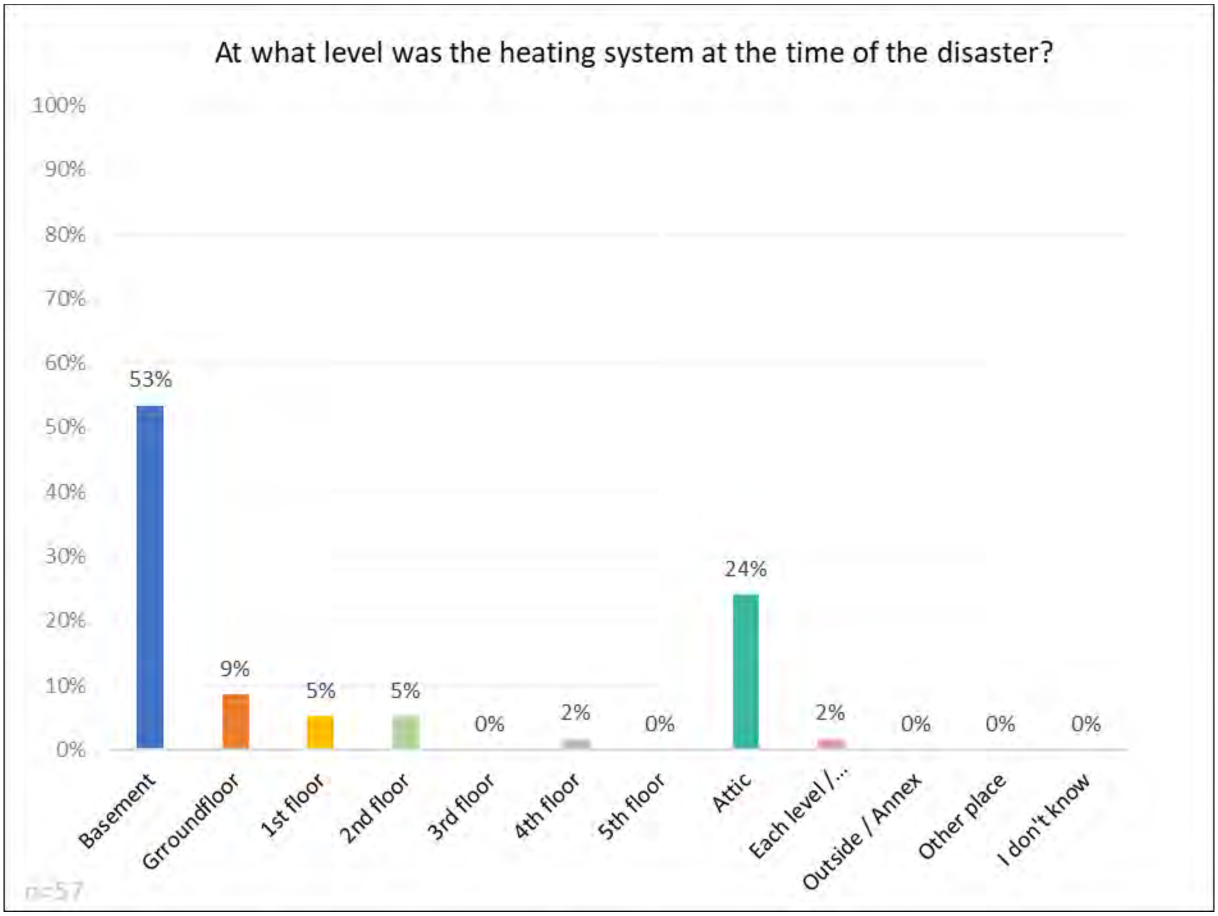



*Figure 94: Percentages of at which the heating system was located before the flood, Netherlands (questionnaire part 2 residential, question 37).*

Figure 223 indicates that the expenses associated with the repair of the heating, electrical, and sewage systems amount to several thousand euros. Damage to the sewage system occurred to a much lesser degree than damage to heating and electrical systems, while Figure 225 indicates a high percentage of damage containing all three categories. In many instances, the specific costs for individual components were not known, and combined damage estimates were more common. This could account for the variation between the data in Figure 223 and Figure 225. The average sum of the damage to the installation systems amounted to 75% between 5.000 and 17.000 euros, see Figure 224.

Figure 95 clearly shows a substantial percentage of the damage inflicted by the flood to interior lining, pavement, and doors. These types of building components are known to be particularly susceptible to moisture and encountering high percentages of damage in such cases is not surprising. Damage to windows and slight cracks are also types of damage present in relatively high percentages. In Figure 226 a distribution of the costs of the main types of damages can be found showing significant amounts of damages in these categories. Also, the damage for doors and doors combined with windows shows that at least multiple doors and/or windows were damaged.

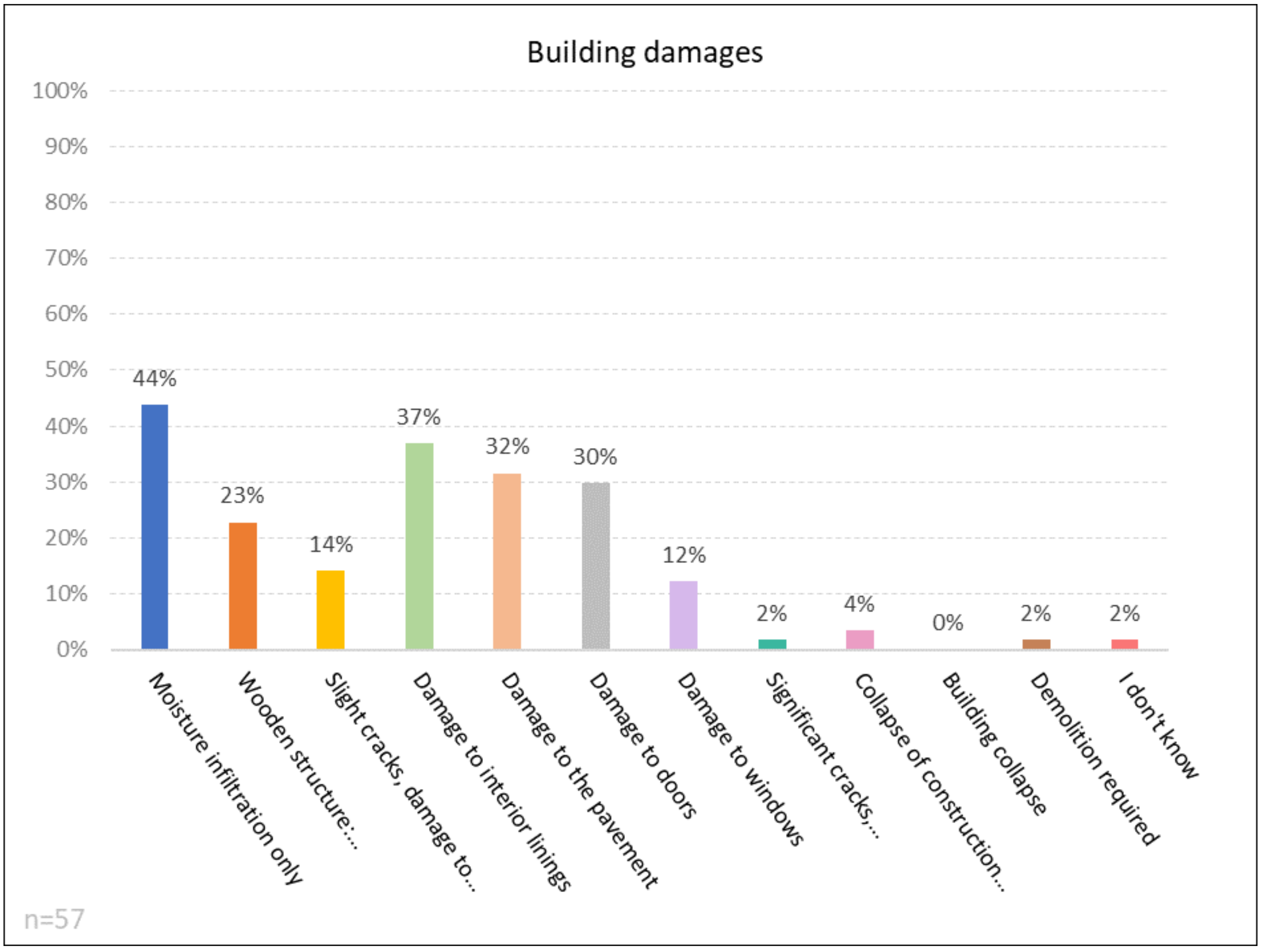



*Figure 95: Percentages of the types of damage which caused the flood at the homes of the participants, Netherlands (questionnaire part 2 residential, question 44).*

What the participants attribute the damage of their building to can be seen in Figure 96. The water level itself is seen as the main cause of the damage but velocity, duration and sediments were also mentioned a lot.

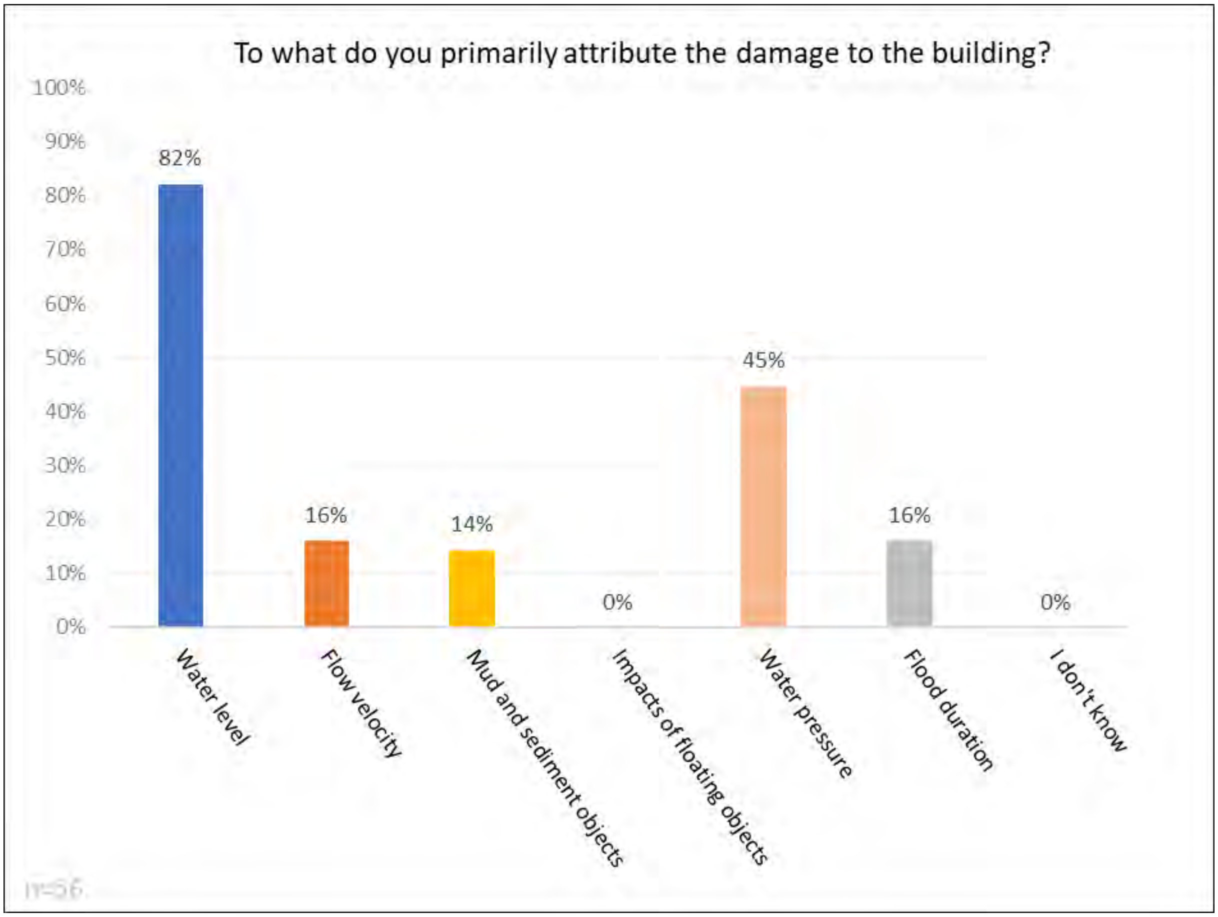



*Figure 96: Percentages of the cause to which the participants attribute the damages to their building, Netherlands (questionnaire part 2 residential, question 49).*

The total costs inflicted by the flood to the building itself are substantial, with damages up to 250.000 euros as can be seen in Figure 97. Half of the damage cases show damage between 35.000 and 80.000 euros. These figures unmistakably illustrate the substantial building damage caused by the event of July 2021.

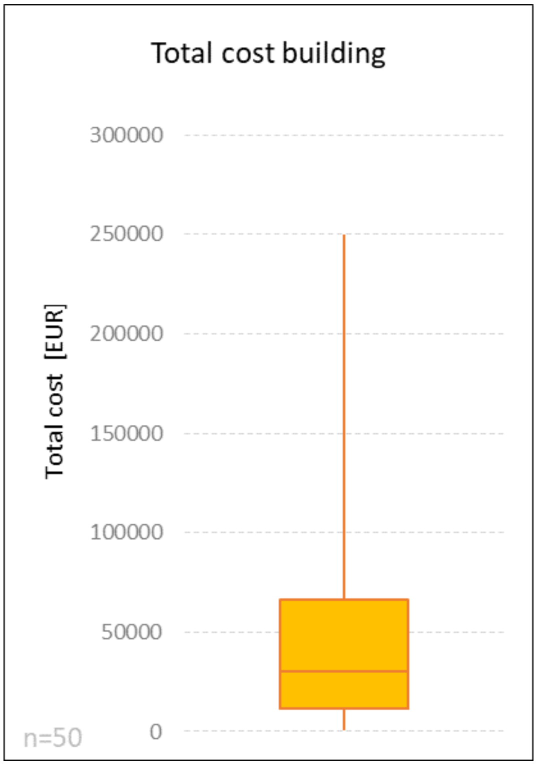



*Figure 97: Box plot of the total costs of all reparation work on and in the building, (material and labor), Netherlands (questionnaire part 2 residential, question 50).*

Also, for the cleaning of the building after the flood, several questions were asked, resulting in the graphs of Figure 230 showing the amount of cleaning hours and the compensation for this by the insurance. In Figure 233 shows the financial building damage approved by the insurance companies. These numbers show the high costs of the flood. It can be noted that the approved numbers are lower than the total building damage expense mentioned in Figure 97. How the approved damage of the insurance matched the building damage differed widely among the participants.

More than half of the participants mentioned a variety of days they had to leave their building due to the flood, 56% had to leave the building (Figure 98 and Figure 99). The variety in duration differed due to available contractors, the severity of the damage and the location of the damage. Some people mentioned staying at home though the basement and or ground floor were flooded.

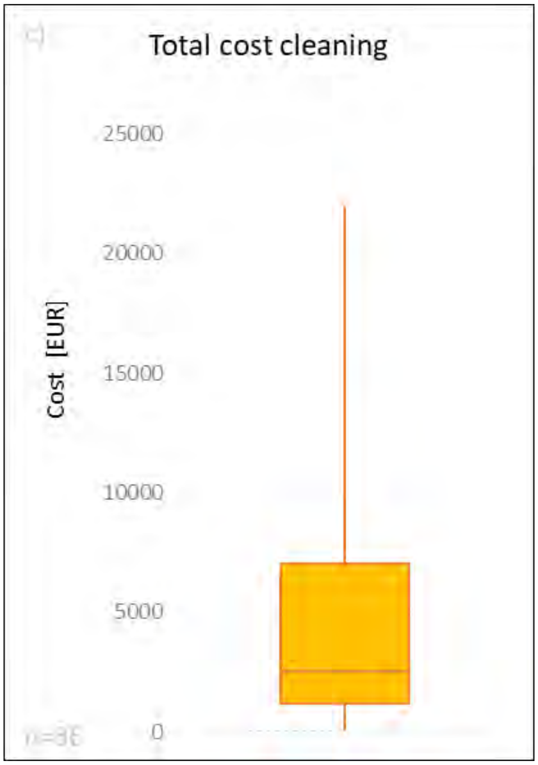



*Figure 231 the dehumidification costs, decontamination costs and the total cleaning costs are shown. The total cleaning cost distribution is shown in Figure 232.*

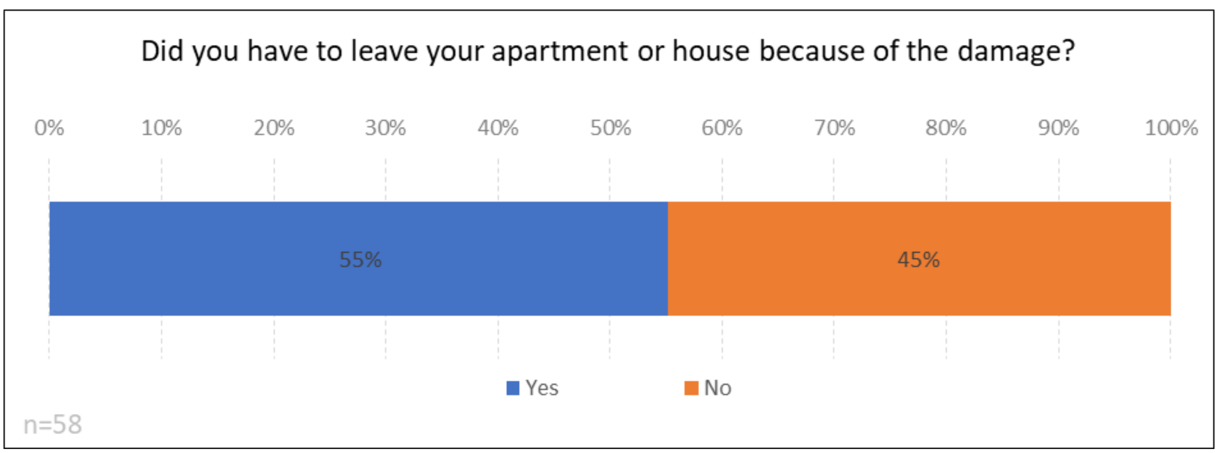



*Figure 98: Percentage of participants who had to leave the house because of the flood in July 2021, Netherlands (questionnaire part 2 residential, question 62).*

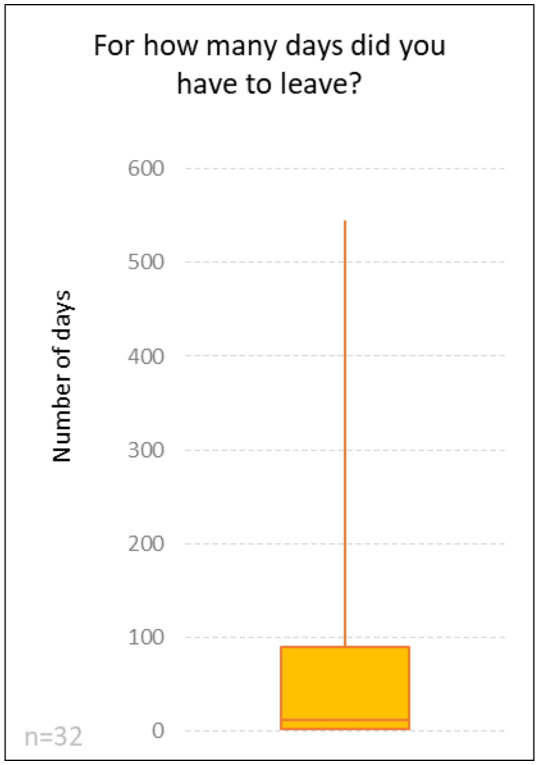



*Figure 99: Box plot of the number of days the participants had to leave their house because of the flood in July 2021, Netherlands (questionnaire part 2 residential, question 63).*

Figure 100 reveals that a minimum of 63% of the affected individuals had fully repaired their buildings within two years of the flood, and many took advantage of this period to enhance their homes beyond their pre-flood condition. However, it's important to note that there are still a significant number of people who have unresolved building damage, which remains (partly) unrepaired in comparison to the pre-flood state. The duration to restore the building, a median of 8 months is high and shows a of lot people were living in unfinished buildings for a while.

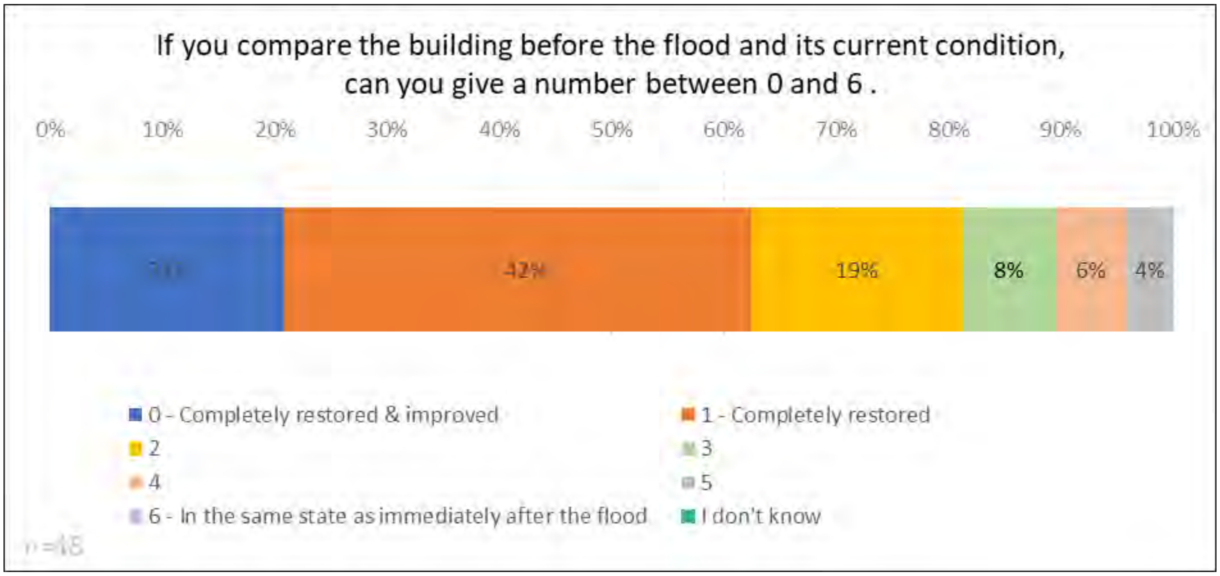



*Figure 100: Percentages of the assessment of the condition of the building, Netherlands (questionnaire part 2 residential, question 64).*

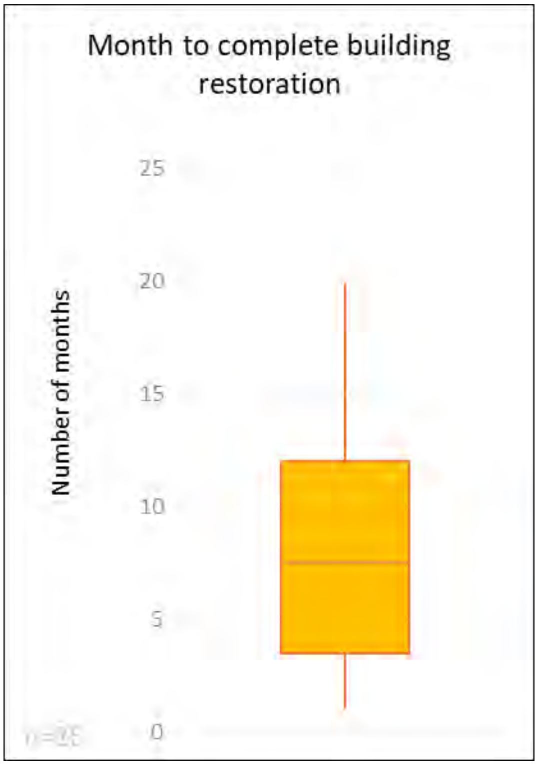



*Figure 101: Box plot of the number of months the participants needed to fully recover their building, Netherlands (questionnaire part 2 residential, question 65).*

Figure 102 shows that the majority received financial help from the insurance. Despite this high percentage of people that received financial help from the insurance, 52% mention they did not get all damage approved, see Figure 234. The group of people who didn't receive financial help from the insurance consist of people who mentioned not having declared any money because of small damages but also consisted of people who didn't get any damage approved. Financial help from donations and governmental sources are both around 32%. The WTS, which is a form of governmental help was mentioned multiple times during the survey to be very vague and not consistent in situations where damage was approved.

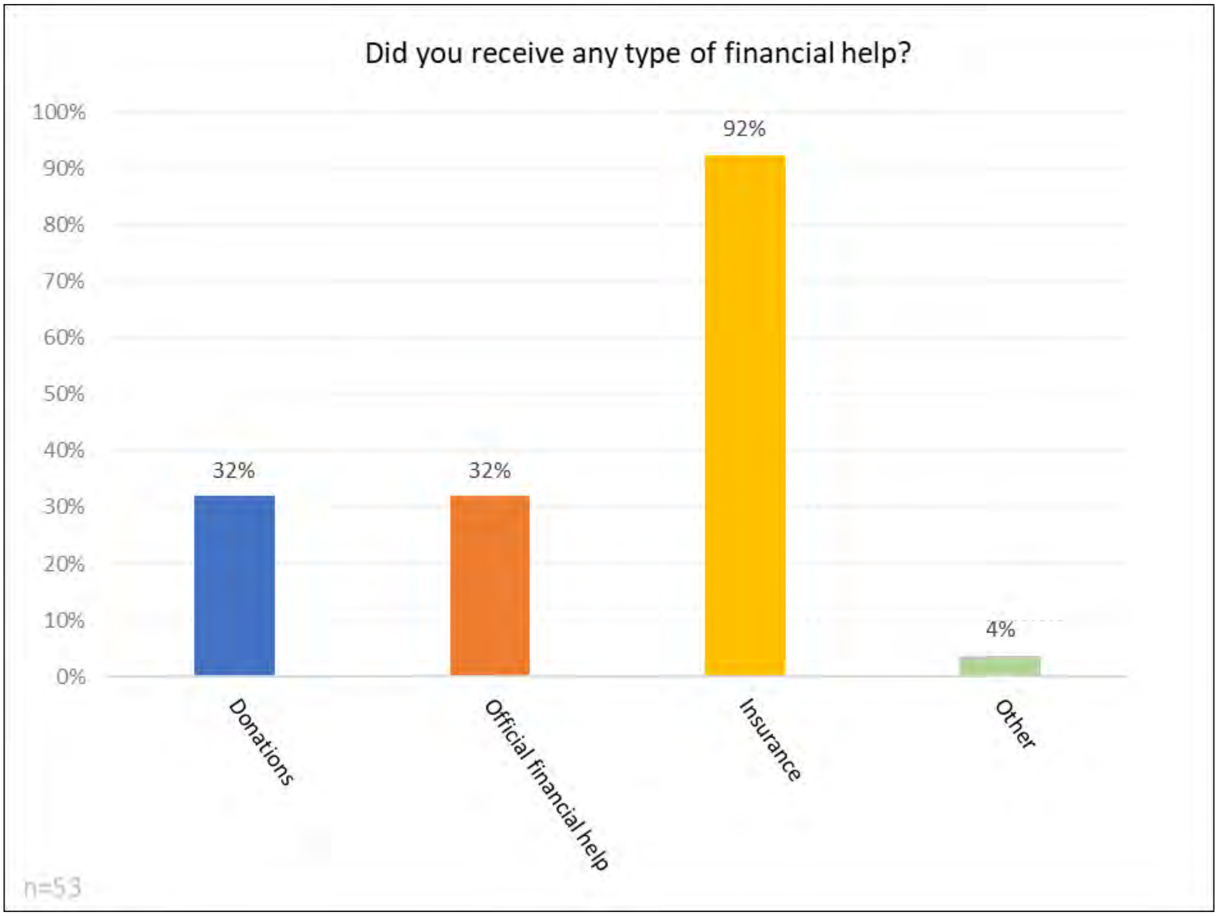



*Figure 102 : Percentage of types of financial help participants received, Netherlands (questionnaire part 2 residential, question 66).*

Figure 102 "financial aid overview" shows the distribution of received financial help. The total received financial help shows this is very similar to the approved amount by the insurance company. This indicates that the amounts of donations and governmental help were marginal compared to what the insurance company approved.

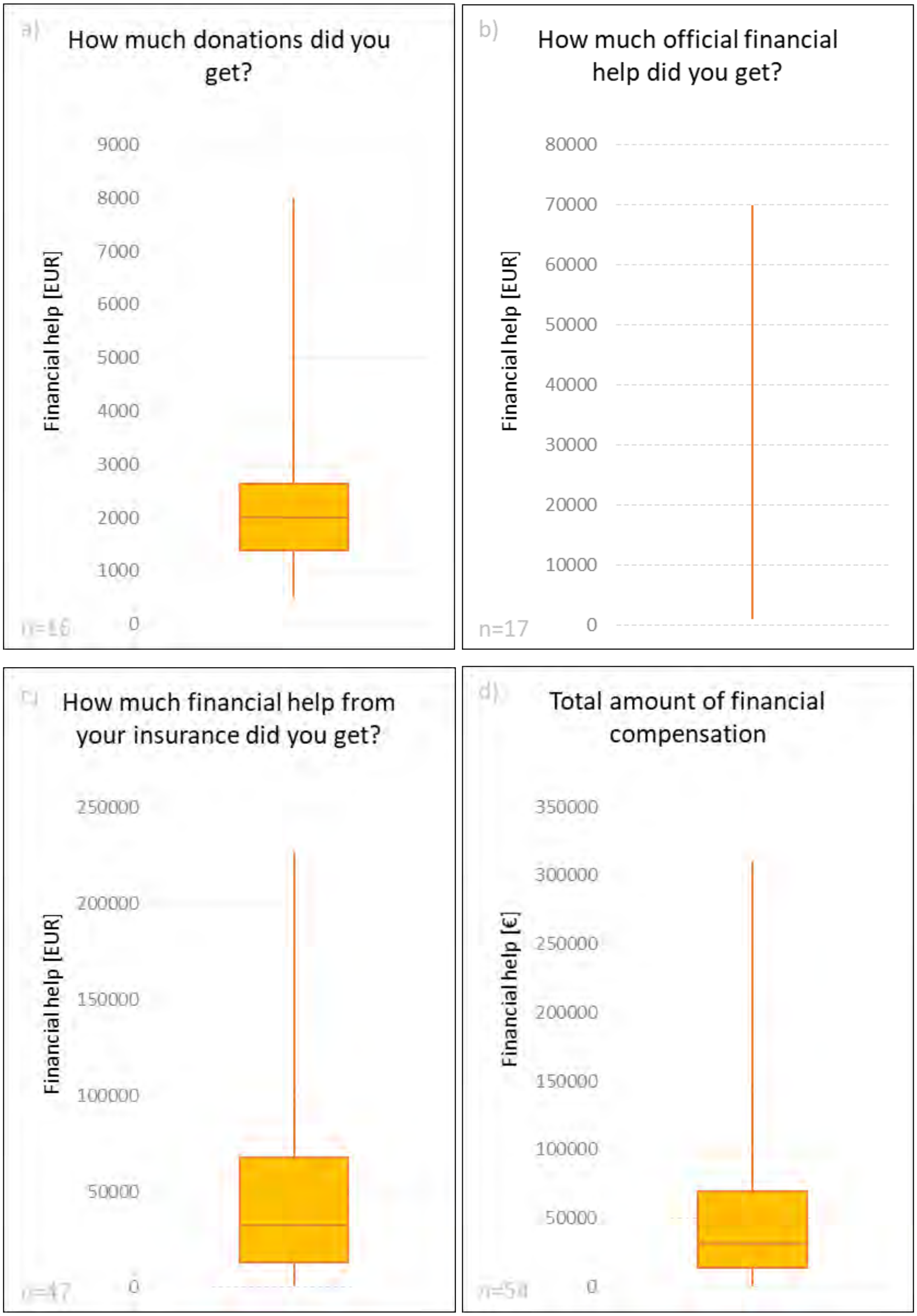



*Figure 103: Box plots amount of financial help a) amount of donations, b) amount of official financial help, c) amount of compensation by the insurance, d) total amount of financial compensation, Netherlands (questionnaire part 2 residential, question 70 – 73)*

From the question about further needs that have not been addressed by far the most mentioned comment was to improve the way of communication. No warnings were issued in Valkenburg via the emergency canals. The list of mentioned needs can be seen in Table 32. The list of what could have been done better in Table 33 is very similar to the list of what needs were still left. The issue of not receiving any warnings comes clearly back in the percentage distribution of Figure 104. The people who mentioned to have received a warning were based on personal observations, warnings from neighbours or online news as can be seen in Figure 235. All types of warnings left not much time to prepare for the flood that was coming as in many cases the flood already started. Question 79, which asks about the time, between the received warning and the arrival of the flood at the house, were answered by only two participants (three hours, four hours).


*Figure 104: Percentages of people who got a warning about the possibility of a flood or not and if yes, when, Netherlands (questionnaire part 2 residential, question 76).*

A few people mentioned having some time to implement precautionary measures after receiving the warning. This meant mainly placing sandbags and/or moving items to higher floors. Activities of the questioned people that were already in place/during the event, carried out within 6 months after the flood or were not planned can be seen in the overview of Figure 238. This answer regarding getting insurance was not correctly asked since almost all questioned people had insurance. Noticeable is that 40% of the people have searched for individual flood protection methods after the flood. Registering to warning systems and consulting hazard maps were rarely done. It needs to be noted that many people in the Netherlands are automatically receiving NLalert warnings when issued. Regarding the short-term mitigation measures evacuation, preventive power cut-off, pumps and some water protection method were in place during the flood. Where pumps and water protection method were also mainly placed after the event as a result of the flood.

The reasons for not implementing certain prevention measures vary according to the results of the survey. It can be clearly seen from Figure 105 that many people were overwhelmed by the event but also mentioned that something like this event should not happen again. A third of the answers show people are not interested in measures performed by themselves. This shows again that an event like this should not happen again in their opinion. Long-term mitigation measures are not too often considered and applied among the questioned people as can be seen in Figure 238.

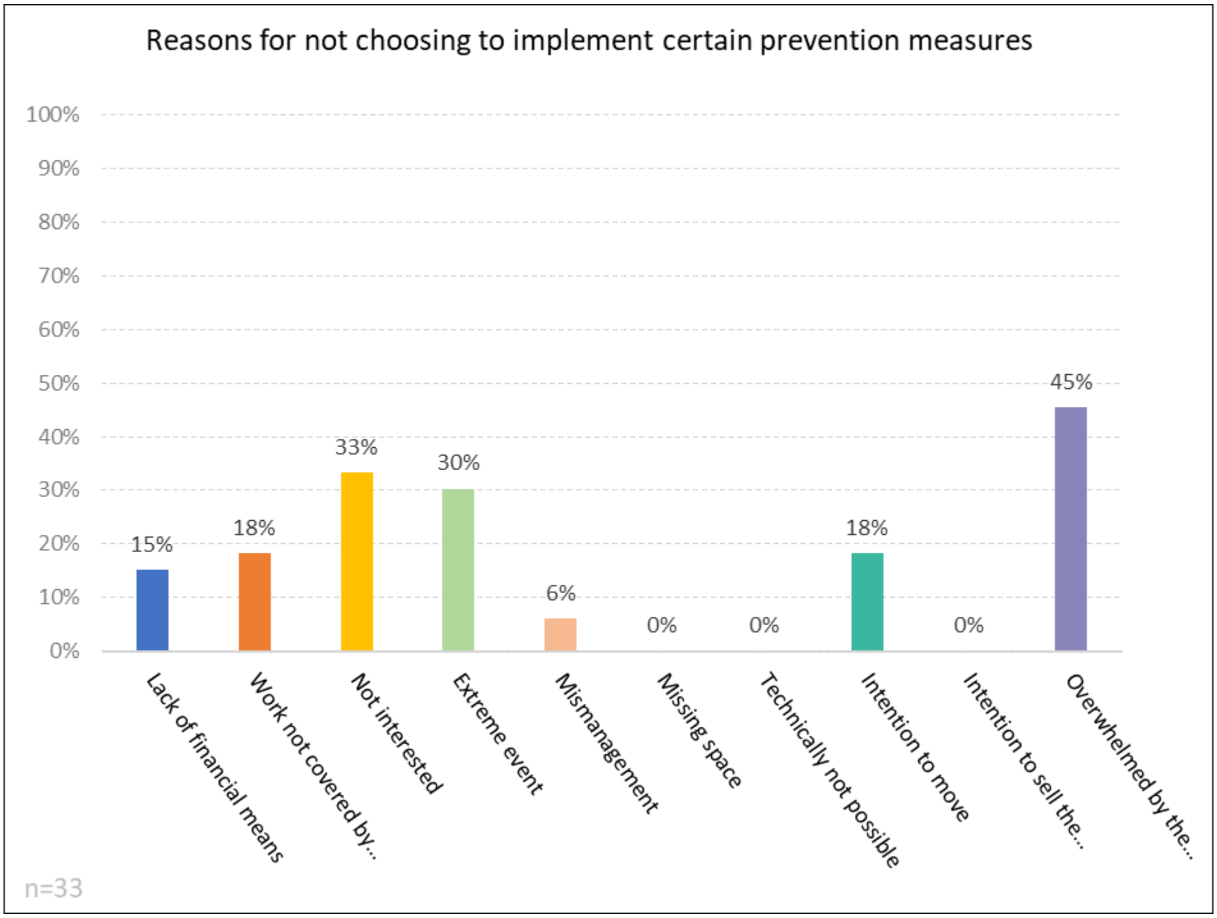



*Figure 105: Percentages of reasons, participants did not choose to implement certain prevention measures following the event, Netherlands (questionnaire part 2 residential, question 84).*

The rareness of the flood event for Valkenburg and Gulpen-Wittem is seen in the high percentage of people being affected by a flood for the first time. The percentage of people affected by a flood at the same address multiple times is only 19%, According to the results of Figure 106. The moments of previously experienced flood events vary, but most are around 1985 and around 1993.

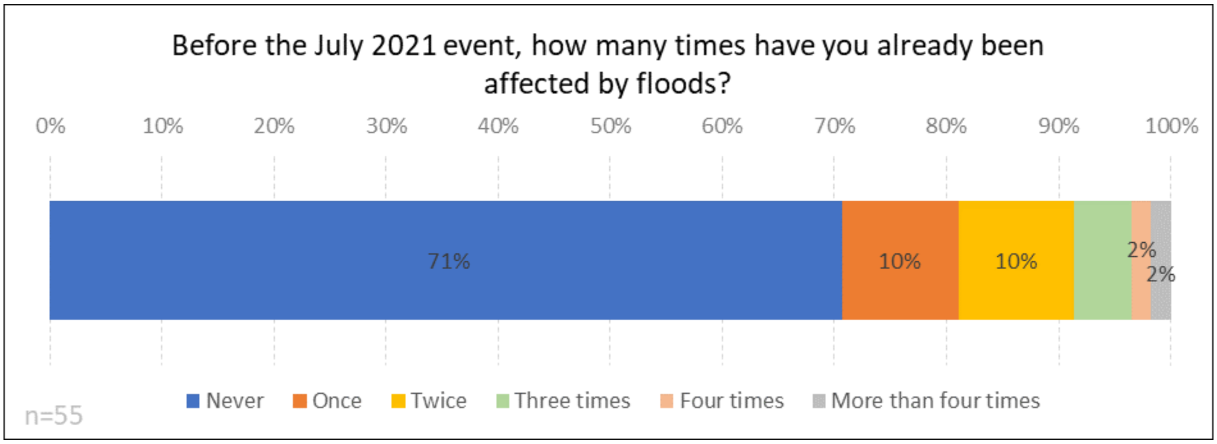



*Figure 106: Percentages of participants who were affected once or several times by a flood before the event in July 2021, Netherlands (questionnaire part 2 residential, question 85).*

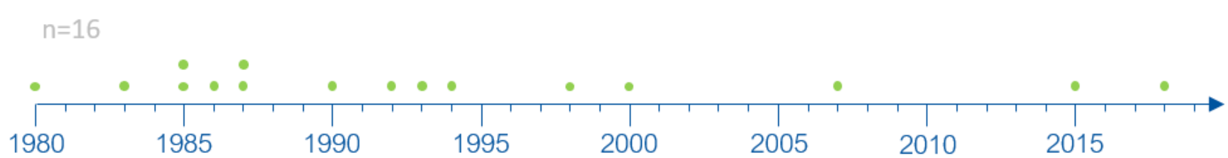



*Figure 107 : Year of the last time when participants were affected by floods before, Netherlands (questionnaire part 2 residential, question 86).*

### 4.3.4 Part 2 (Commercial sector)

In the Netherlands, there have been conducted a questionnaire to commercial buildings. In this questionnaire, similar questions as for the residential part have been asked. Some questions are slightly adapted to fit better with the commercial sector. There have been 14 surveys conducted on commercial buildings, which were all performed in the field. This means that the dataset is a lot smaller than the residential building dataset, which makes it statistically more difficult to tie conclusions to the data. Nevertheless, it is very interesting to take these surveys into account and analyse them. The duration of the commercial surveys took less time than for the residential surveys, as can be seen in the duration distribution graph of Figure 240.

The water depth of the commercial questioned buildings at the front door and at the maximum water depth against the building are very similar. The commercial buildings were mainly in the old city centre of Valkenburg where there is little elevation difference around each building and no gardens. The experienced water depth was for the majority of the commercial buildings around 1.1 meters, an overview can be seen in Figure 108. Around 86% of the questioned businesses were owned by the participants (Figure 242). Also, 86% (12 businesses) of the questioned businesses were of the type service industry, 1 retail shop and the remaining of the “other” category was a church (Figure 109).

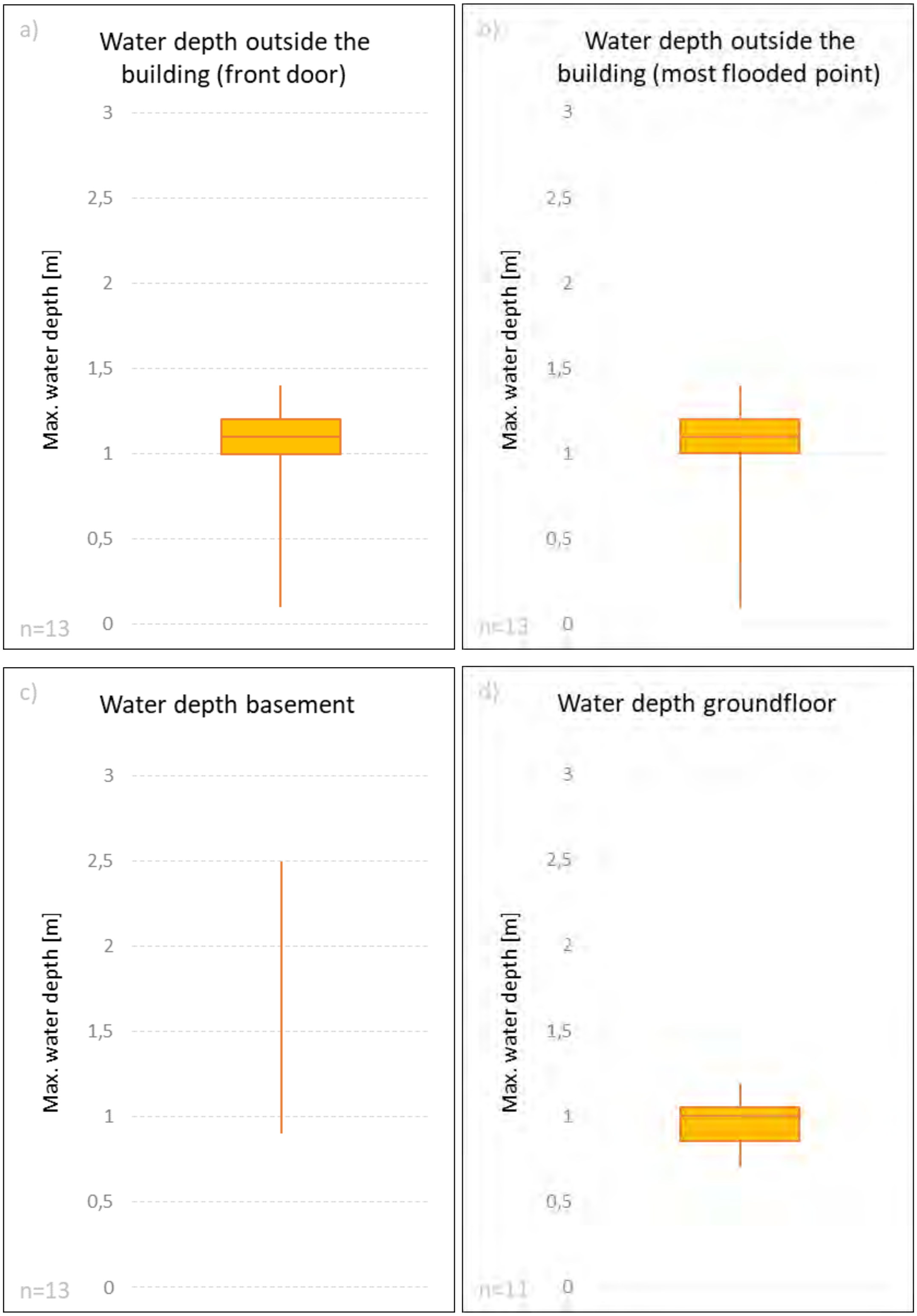



*Figure 108: Water depths, Netherlands (questionnaire part2 commercial, question 3).*

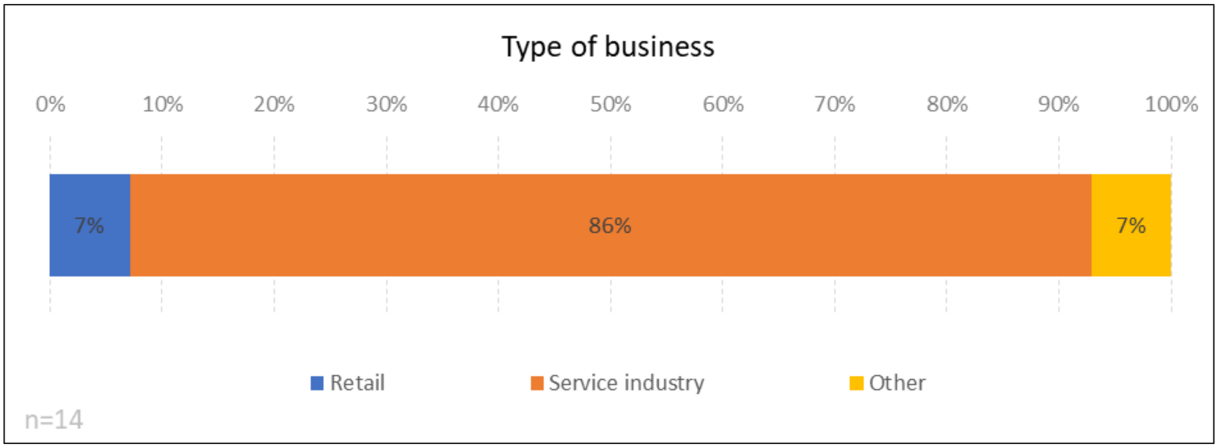



*Figure 109 : Percentages of different types of businesses in the survey, Netherlands (questionnaire part 2 commercial, question 5).*

The majority of the businesses attributed the flood of their business to runoff and/or overflow of a watercourse. The old city centre of Valkenburg experiences more often inundations by runoff from precipitation events. The overview can be seen in Figure 110. As most of the questioned businesses were in the service industry, a large part of the affected areas were gastronomy areas, a few workshop areas, and some sale areas, see Figure 111.

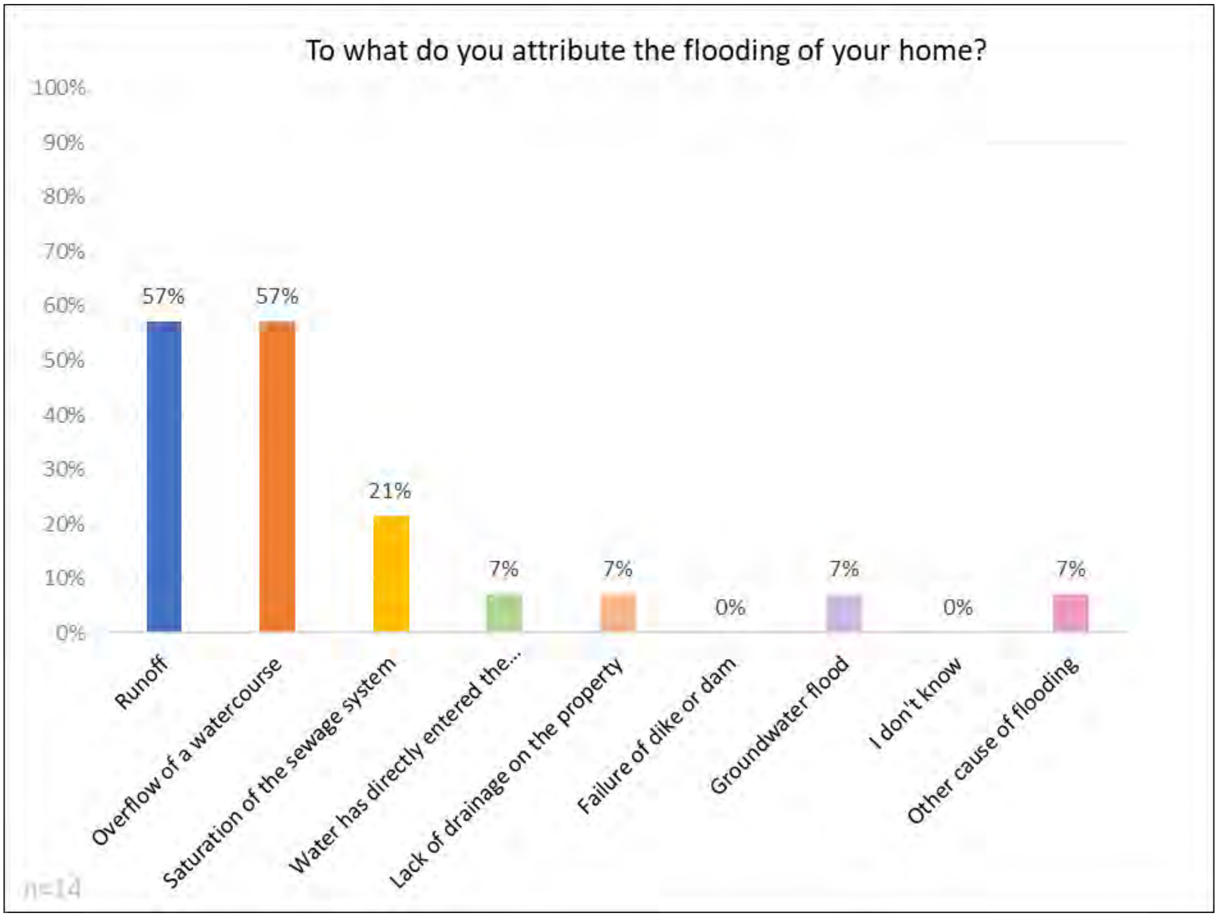



*Figure 110: Percentage of to what the participants attribute the flooding of their business, Netherlands (questionnaire part 2 commercial, question 7).*

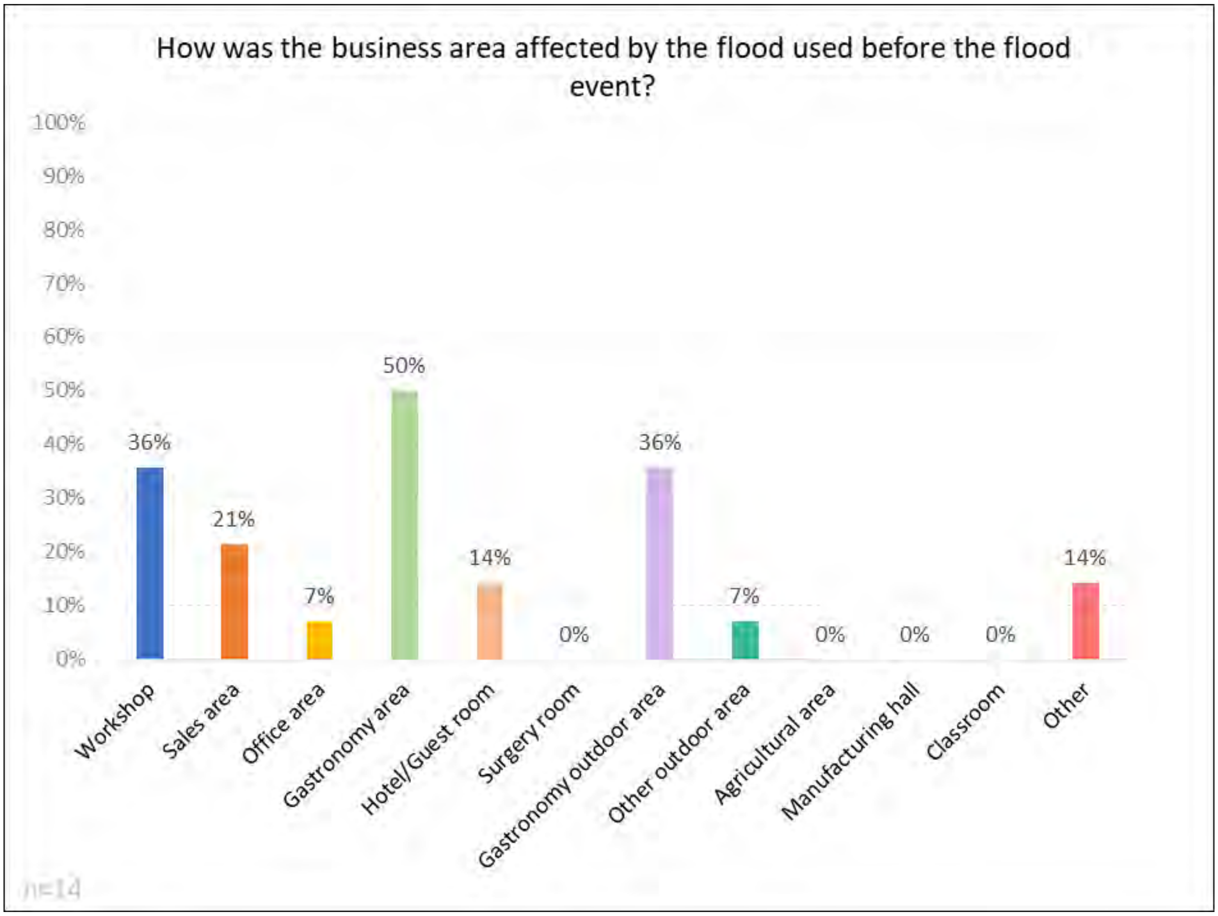



*Figure 111: Percentages uses of the affected area, Netherlands (questionnaire part 2 commercial, question 9).*

All commercial buildings were for a certain period unusable due to the flood. This shows that all 14 businesses experienced hindrance and or damage from the flood already from only not being able to use some areas (Figure 112). The two most mentioned descriptions of the flood situation in front of the building were "should have made effort to stand" and "Would have been swept away", as can be seen in Figure 114. This shows that combined with the water depth of an average of 1 meter, the water was also flowing with some force. The door sills and or the stairs to the front door were for all questioned buildings low, with most below 0.3 meters, compared to the residential buildings questioned where these were much higher, see Figure 211.

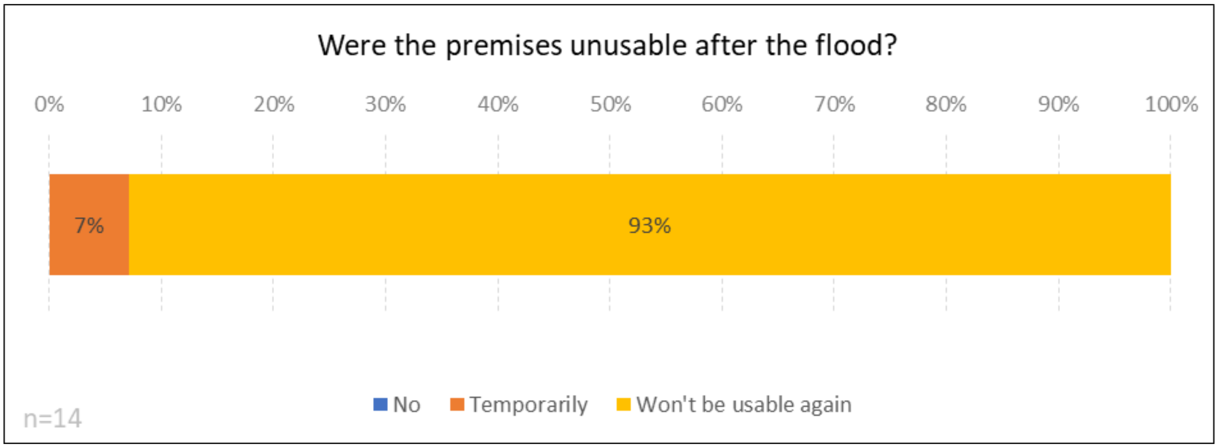



*Figure 112: Percentages of premises that were (temporarily) unusable after the flood, Netherlands (questionnaire part 2 commercial, question 11).*

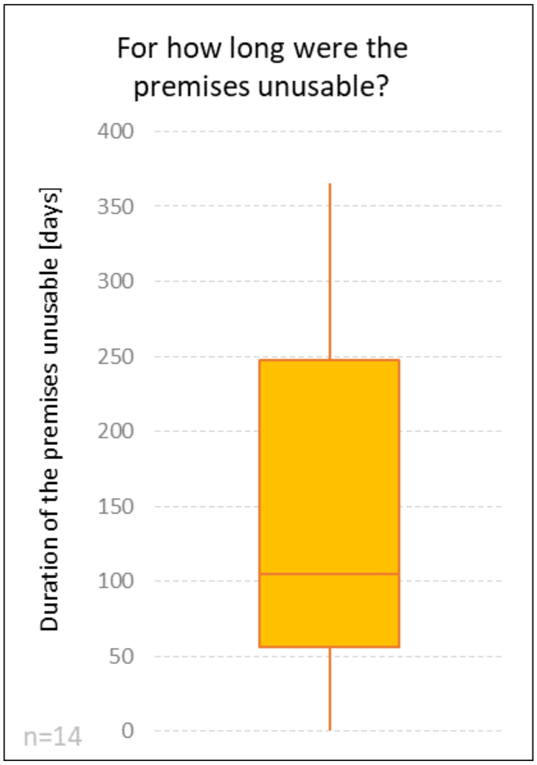



*Figure 113: Box plot of days, premises were not usable, Netherlands (questionnaire part 2 commercial, question 12).*

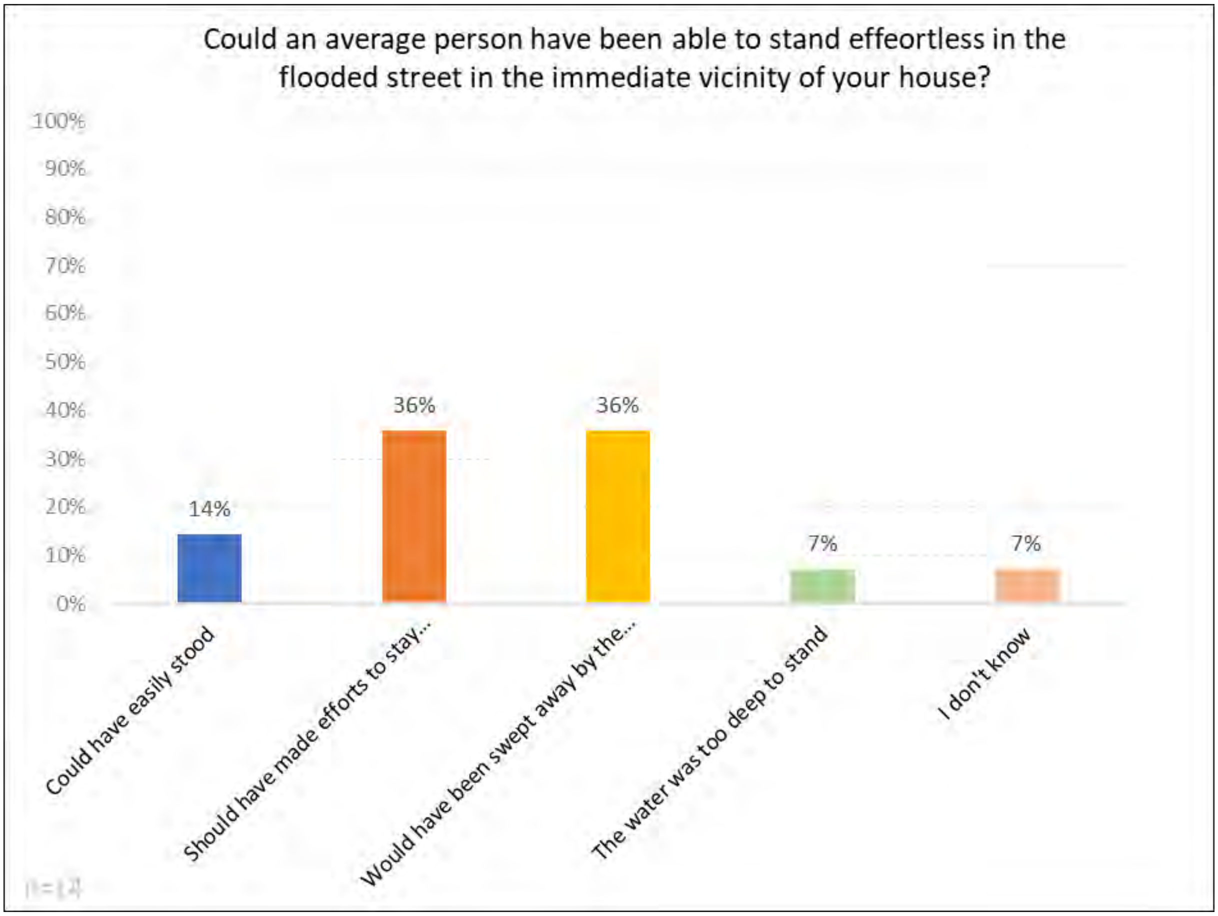



*Figure 114: Percentages of subjective estimates of the magnitude of the discharge/velocity of the participants, Netherlands (questionnaire part 2 commercial, question 13).*

Interesting to notice in Figure 115 is that for the questioned commercial buildings all but one had floodings in the basement and the ground floor, where for the residential buildings more often only the basement was flooded. The low door sill/steps and the high water depth are probably the contributors to this.

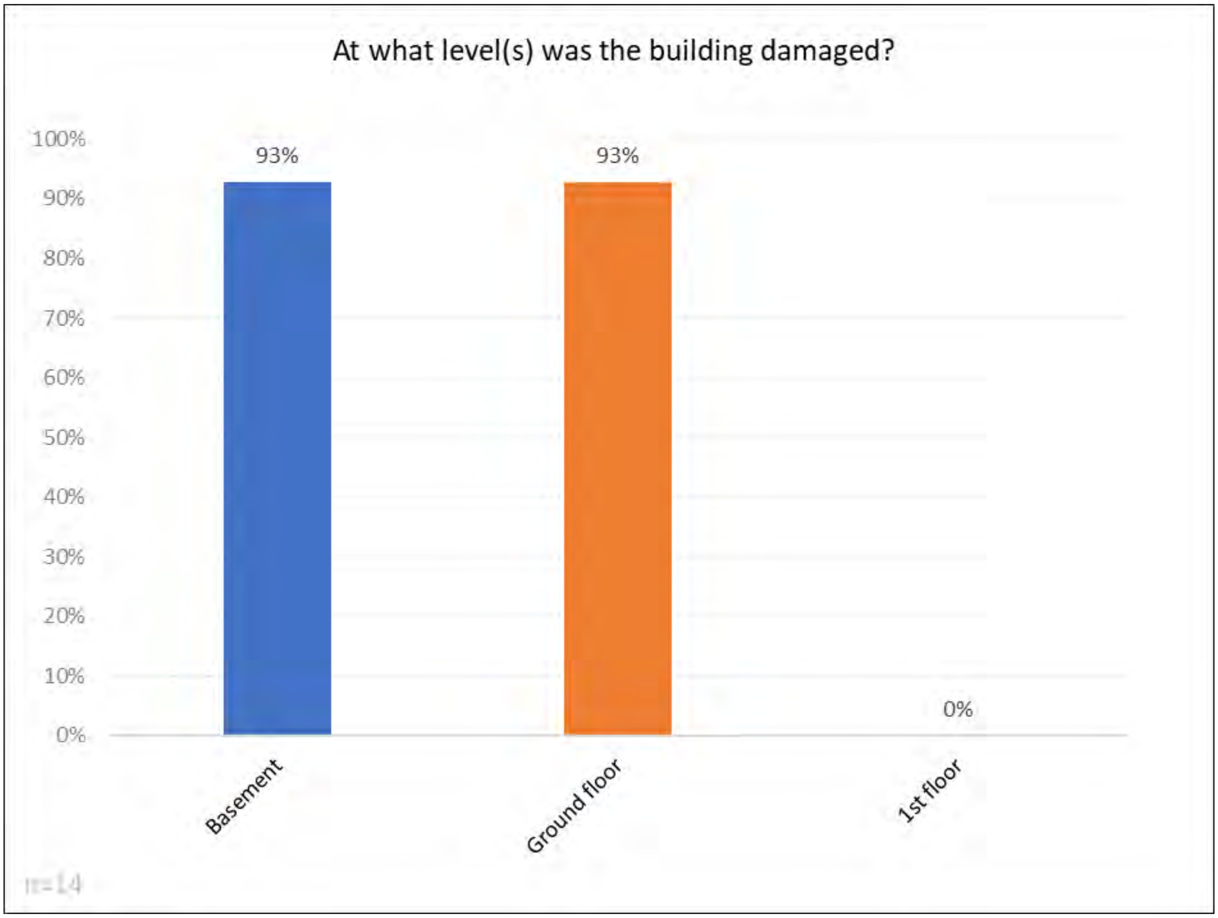



*Figure 115: Percentages of the levels, on which the homes of the participants are damaged, Netherlands (questionnaire part 2 commercial, question 15).*

The businesses were most located on several levels of the building including the basement, all were at least located at the ground floor, see Figure 244. 67% of the basements were (partially) finished and used for e.g. storage. For all the ground floor was used as business and were finished. A high percentage of businesses mentioned mud being transported and deposited in the building, followed by garbage and sand (Figure 116). The transported materials were relatively small (Figure 117). For the commercial buildings, just like the residential buildings the majority indicated that the water was flowing relatively fast with a rate of 4/5 and 5/5 by 64% (Figure 118).

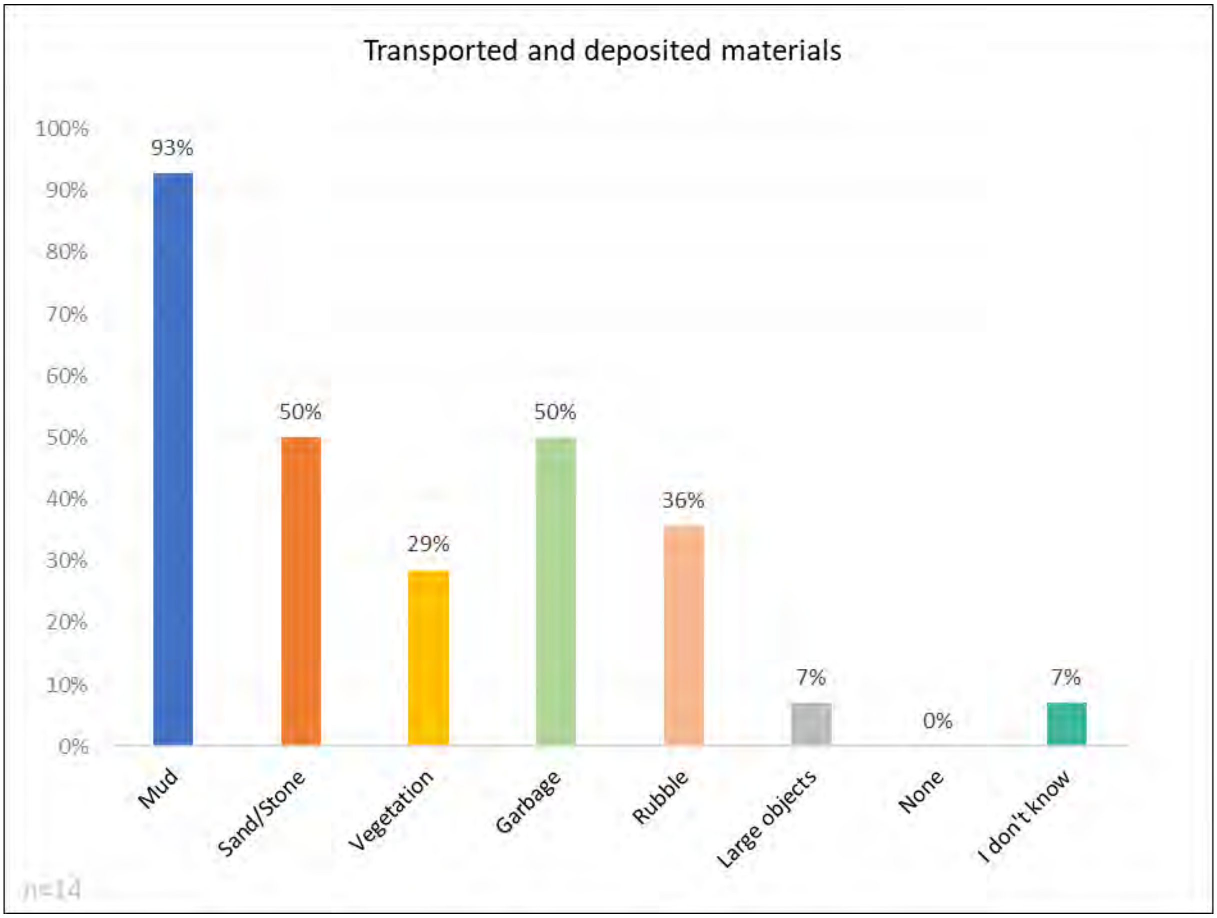



*Figure 116: Percentages of what materials were transported or deposited in the buildings or had direct contact with them, Netherlands (questionnaire part 2 commercial, question 18).*

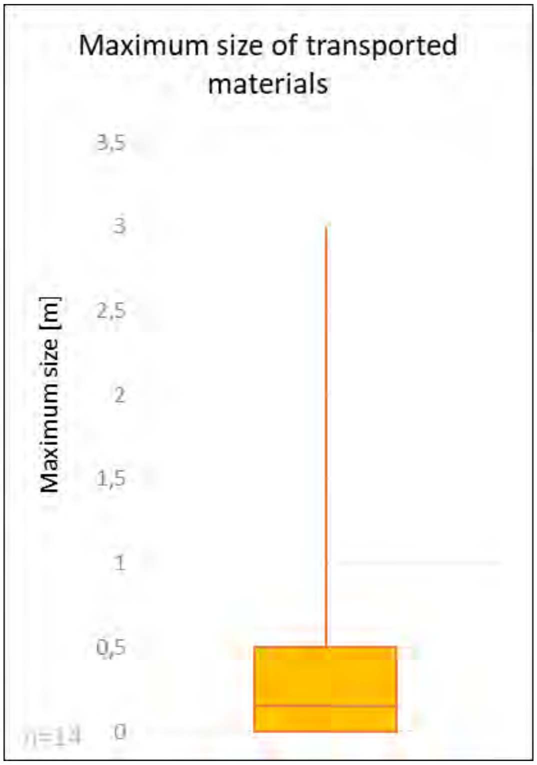



*Figure 117: Box plot of the maximum estimated size (length) of the transported/deposited materials in question 11, Netherlands (questionnaire part 2 commercial, question 19).*

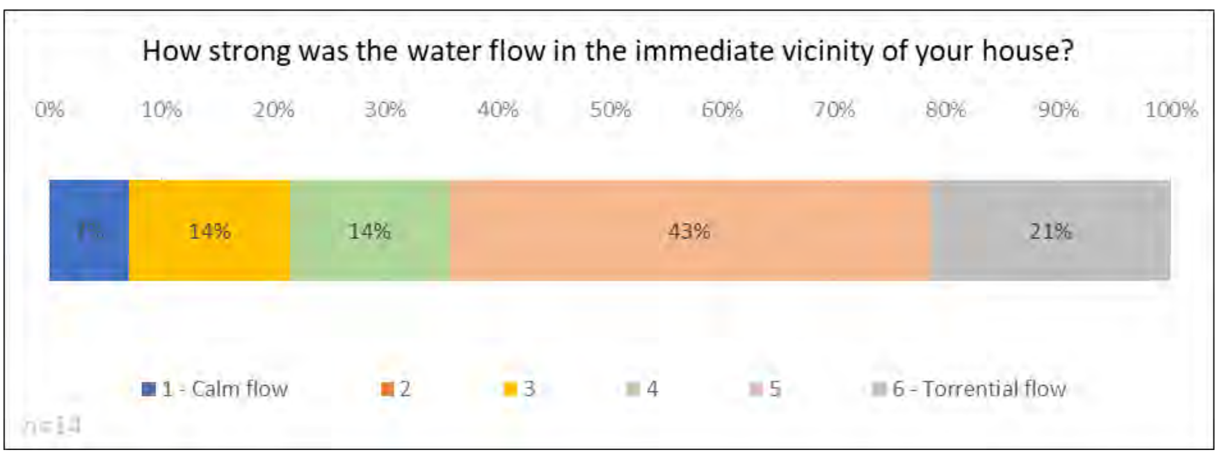



*Figure 118: Percentages of the estimation of the strength of the water flow in the direct vicinities of the participants business, Netherlands (questionnaire part 2 commercial, question 20).*

The majority experienced contamination of the building by chemicals, sewage, or hydrocarbons. A third didn't have any contamination. The ground floor areas of the commercial buildings are overall larger than that of the residential buildings. The ground floor is for almost all commercial buildings larger than 80 $m^2$ (Figure 246).

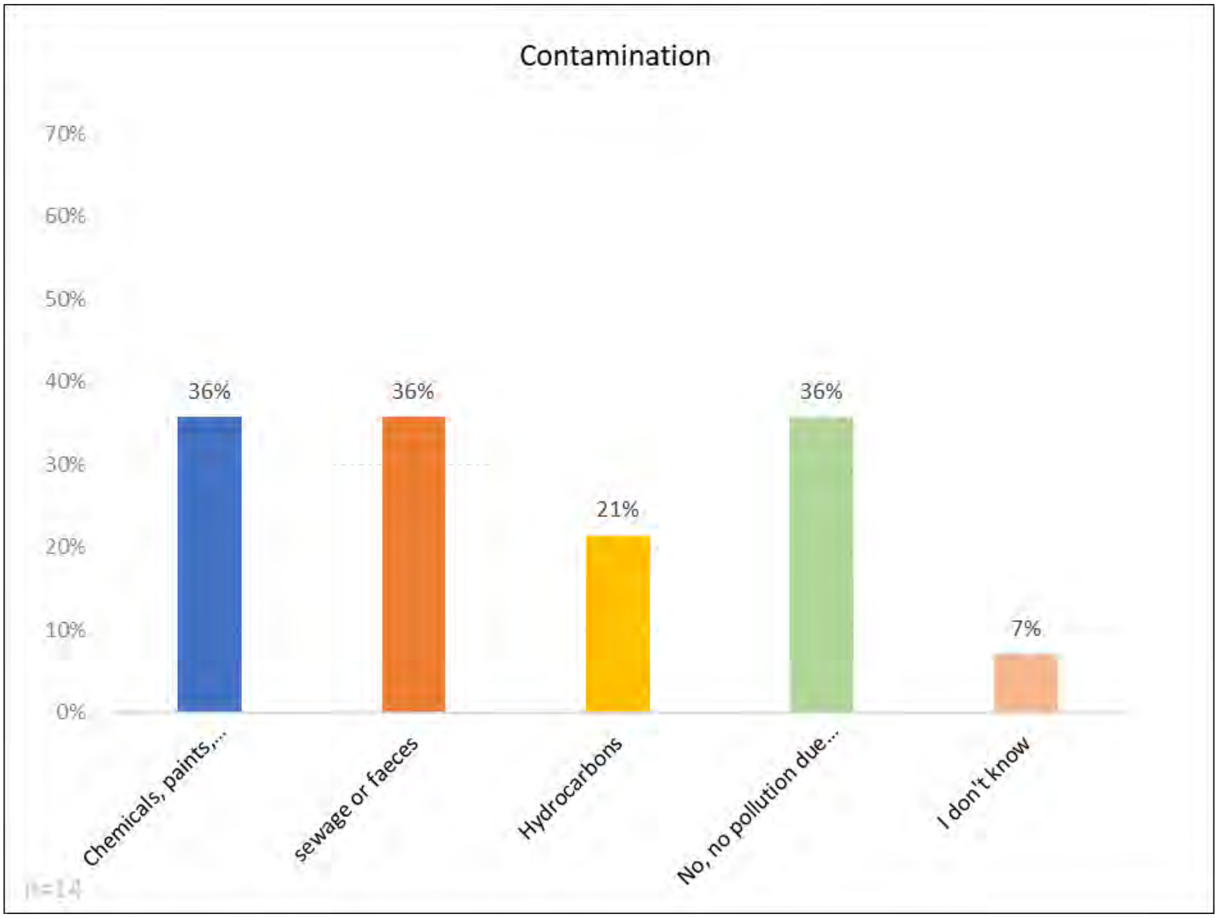



*Figure 119: Percentages of the records of the observed contaminants in the homes of the participants, Netherlands (questionnaire part 2 commercial, question 21).*

As many service industry businesses were questioned a lot of appliances connected to this type were damaged, like ovens, washing machines, dishwashers (kitchen equipment), etc. Only 3 businesses had experienced damage to their cars, and no motorcycles were damaged (Figure 248). The total costs of the damaged sales goods added up for the median of the cases to 100,000 euros which went up to 700,000 euros, see Figure 120. This shows a very high damage number to businesses for only the sales goods. The high damage numbers seen in Figure 120 are the same as in Figure 121 where the damage to the equipment can be seen. Indicating that for some businesses it was difficult to give a number for only the sales goods separate of the equipment.

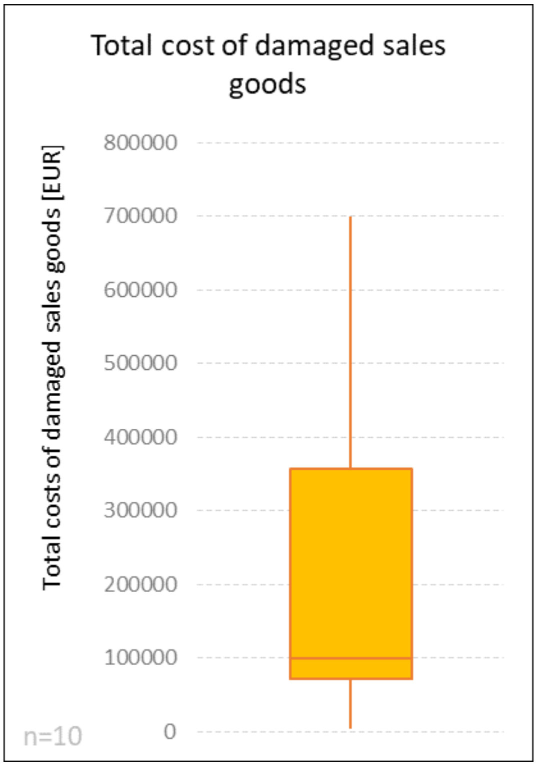



*Figure 120: Box plot of total cost of damaged sales goods, Netherlands (questionnaire part 2 commercial, question 26).*

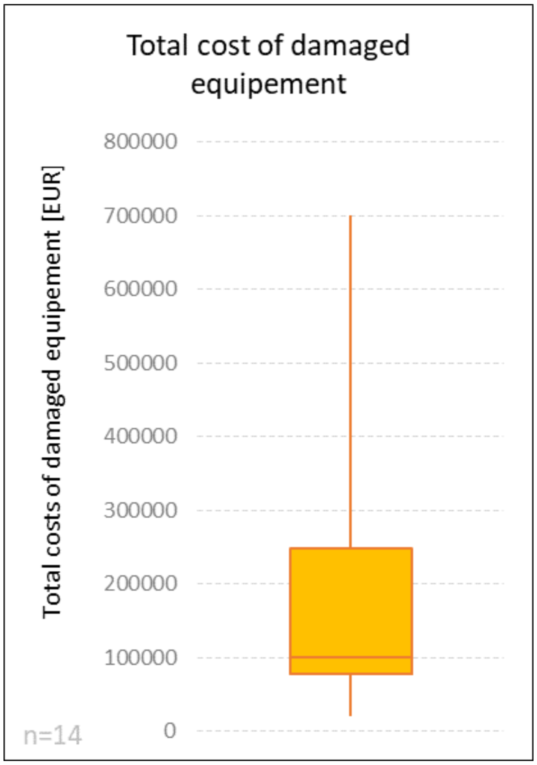



*Figure 121: Box plot of total cost of damaged equipment, Netherlands (questionnaire part 2 commercial, question 30).*

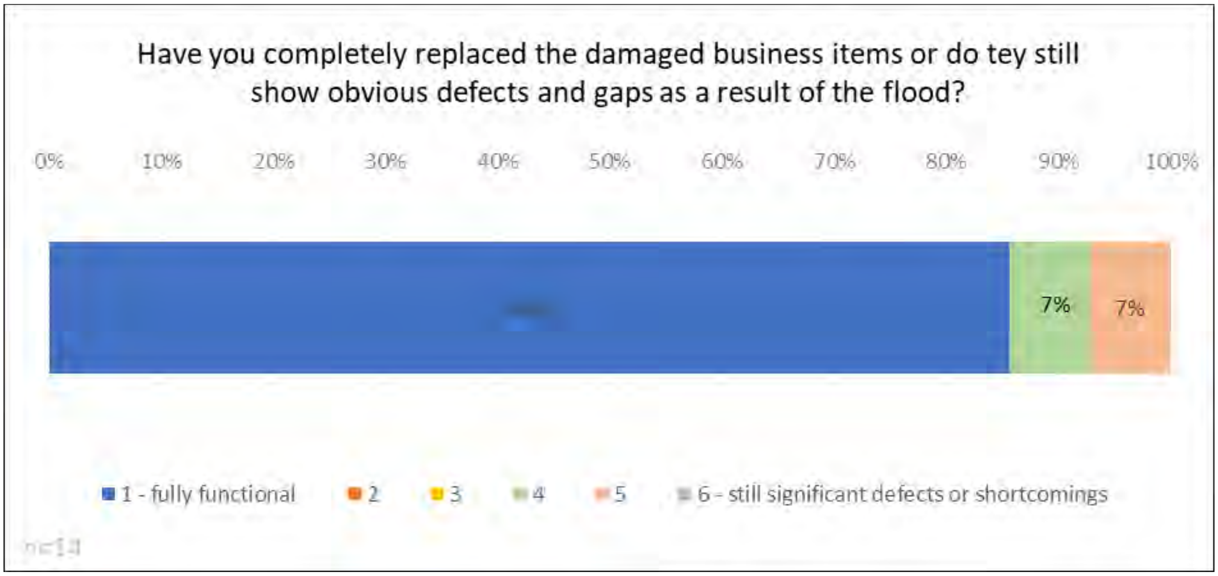



*Figure 122: Percentages of completely replaced the damaged business items and the degree of defect, Netherlands (questionnaire part 2 commercial, question 34).*

The recovery period for the businesses before they could go back to business was relatively long, where the median of the cases was a period of 6 months (Figure 123). Not being able to open your business for such long periods means losing a large number in revenue besides tangible damage to sale goods, equipment, and the building. While some businesses still experience some malfunctions to their equipment (Figure 122).

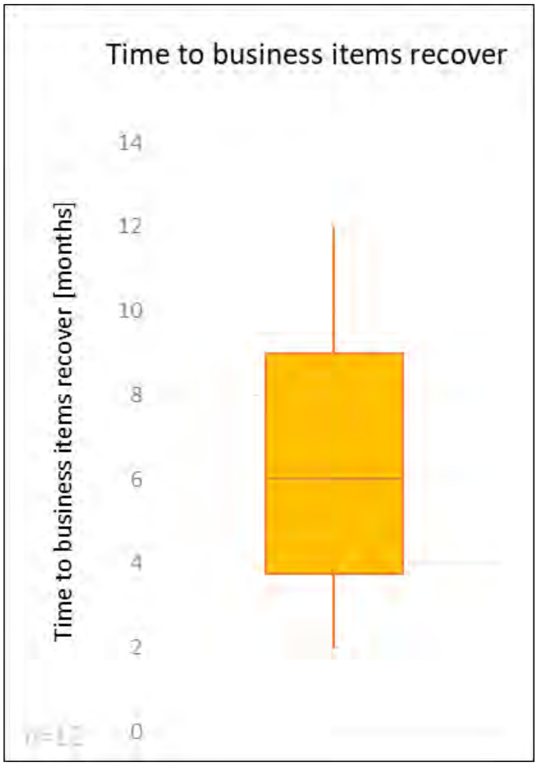



*Figure 123: Box plot of time to business items recover, Netherlands (questionnaire part 2 commercial, question 35).*

The three types of buildings, attached, semi-detached and detached are almost equally represented in the survey. A high percentage of the buildings had 4 to 5-floor levels (Figure 256) and 43% of the buildings were built before 1875. From the construction year of the buildings, it is noticeable that many buildings of the commercial type were visited in the old city centre of Valkenburg. Heating with gas is for these buildings the main source as can be seen in Figure 257.

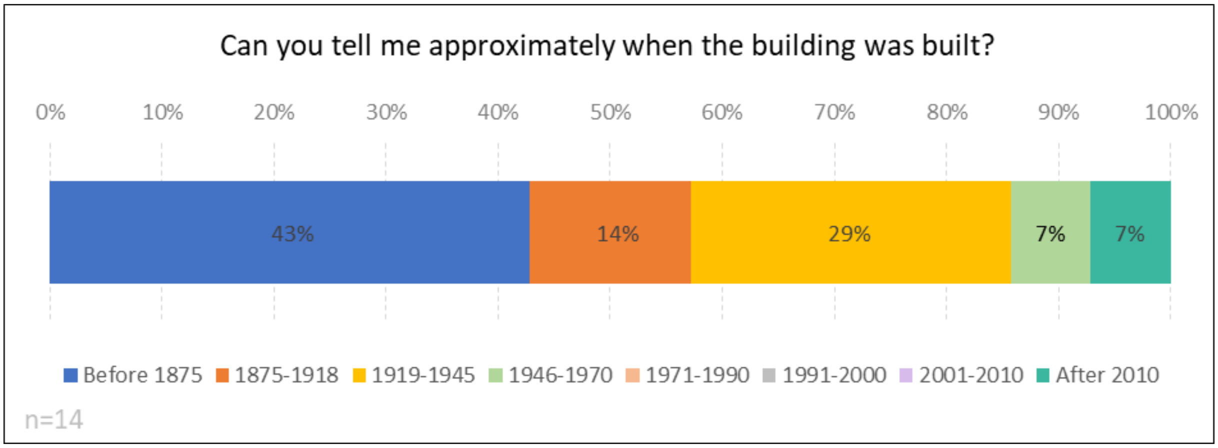



*Figure 124: Building period of the buildings the participants work in, Netherlands (questionnaire part 2, question 41).*

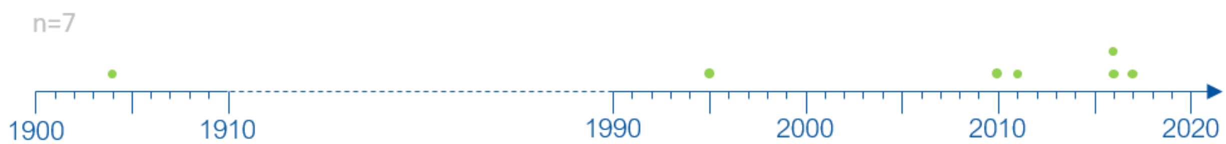



*Figure 125: Last major renovations of the buildings the participants work in, Netherlands (questionnaire part 2 commercial, question 42).*

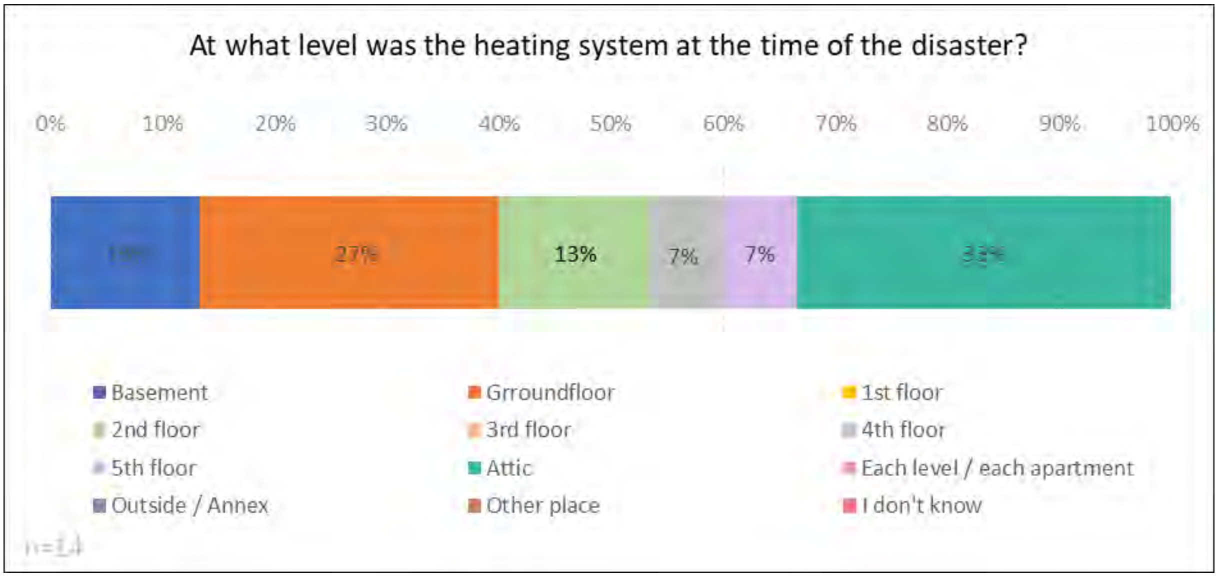



*Figure 126: Percentages of at which the heating system was located before the flood, Netherlands (questionnaire part 2 commercial, question 45).*

Damage to the building itself consisted mainly of moisture infiltration, damage to interior linings, pavement, and doors, see Figure 127 for the distribution of the mentioned types of damage to the building. The costs of these damages are a lot lower the costs of the sales goods and equipment lost by the flood. Most damage is below 200.000 euros, see Figure 128. The reason for these damages to the building were mainly attributed according to the participants to the water level followed by the flow velocity and water pressure (Figure 258).

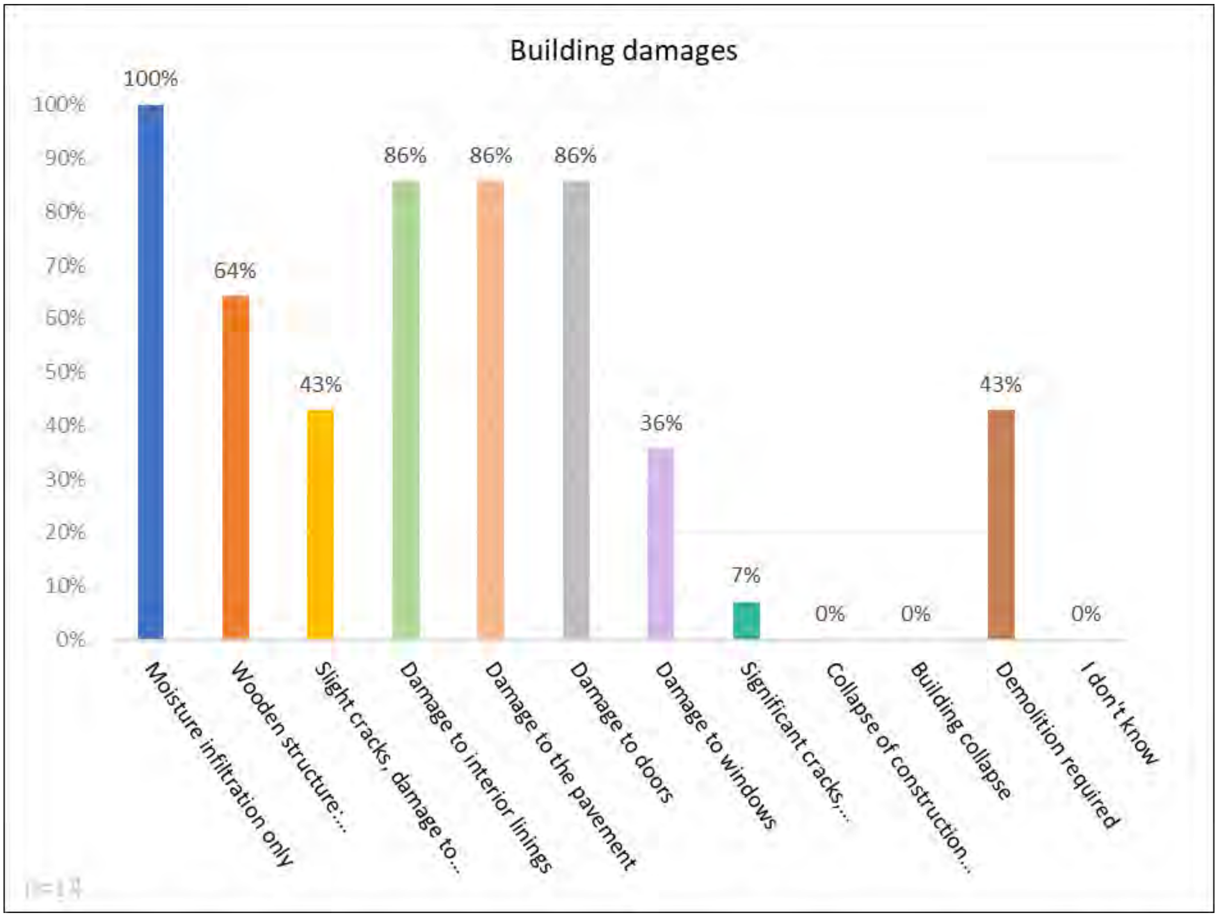



*Figure 127: Percentages of the types of damage which caused the flood at the business of the participants, Netherlands (questionnaire part 2 commercial, question 47).*

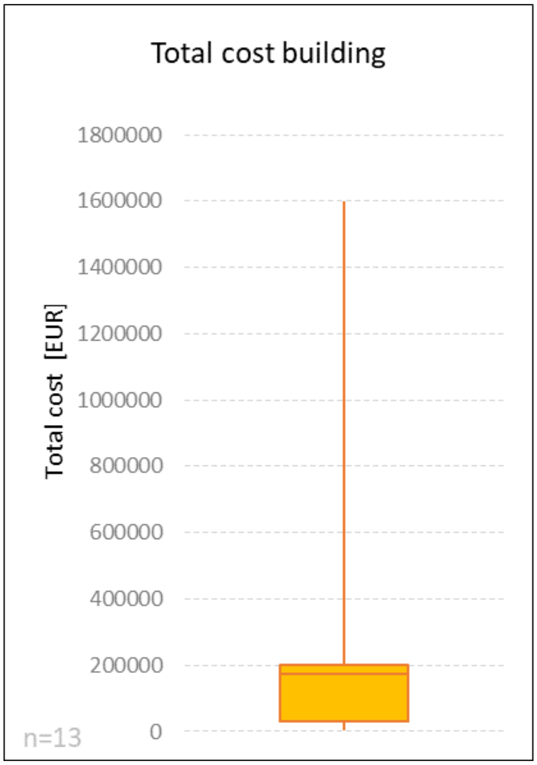



*Figure 128: Box plot of the total costs of all reparation work on and in the building, Netherlands (questionnaire part 2 commercial, question 48).*

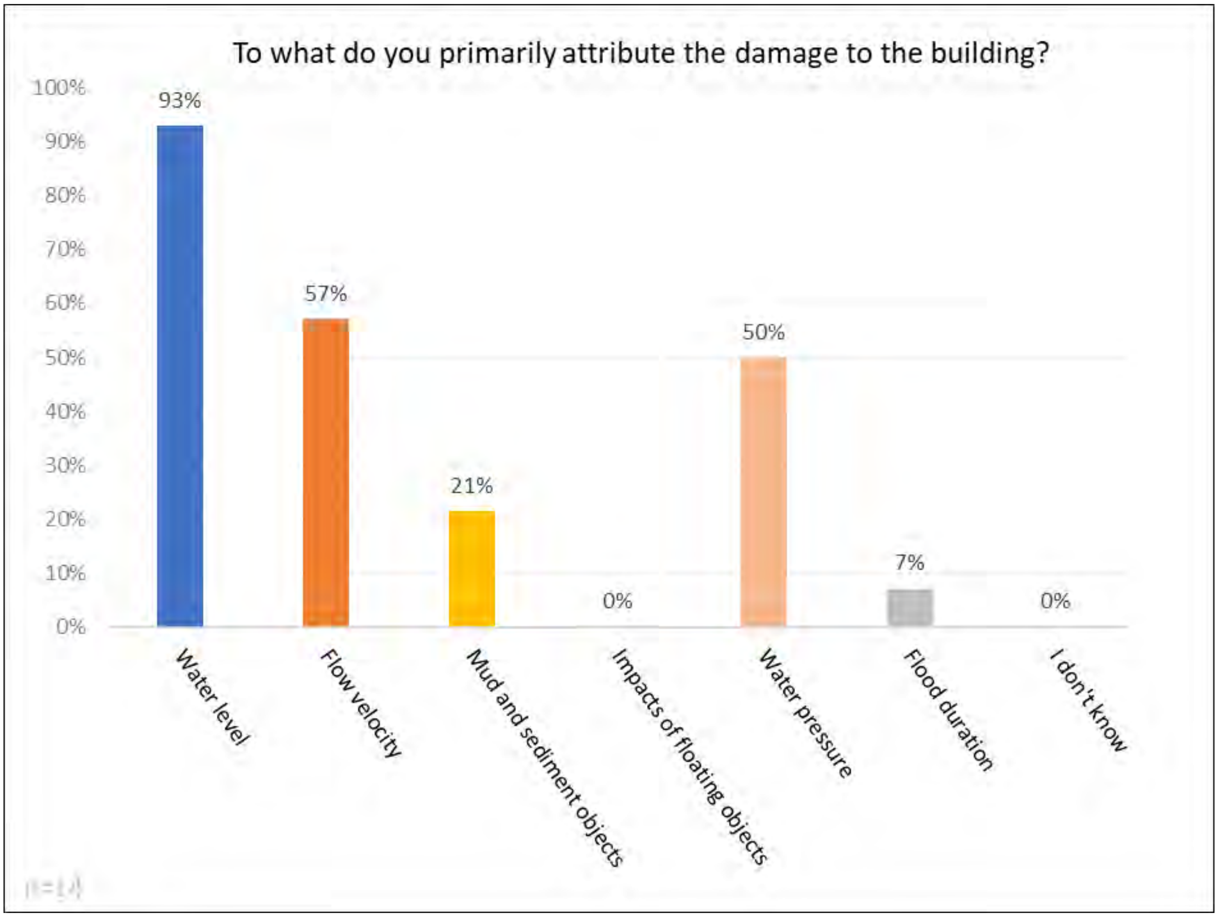



*Figure 129: Percentages of the cause to which the participants attribute the damages to their building, Netherlands (questionnaire part 2 commercial, question 53).*

An overview of the cleaning hours and costs can be found in Figure 261. Compensation for cleaning was much higher than seen at the residential buildings. The building footprint area could play a role in this, as this was much larger in the commercial sector. Costs for dehumidification and the total costs can be seen in Figure 262.

The damage approved by the insurance was for the majority of the questioned businesses below 426,000 and went up to 5,000,000 euros, see Figure 264. For all the businesses who could answer this question (12 businesses) mentioned damage to the building and equipment damage was included in the approved damage by the insurance. 11 businesses also had sales goods included in this number and 8 businesses had even loss of turnover included in this number, see Figure 265. Some participants mentioned that the profit loss was difficult to calculate due to the influence of corona on the year numbers, which also resulted in deviating financial numbers compared to the years before. All the businesses needed to close due to the flood of July 2021. The closure lasted for a long period and was for all but one of the buildings due to reconstruction time, see Figure 131 and Figure 266.

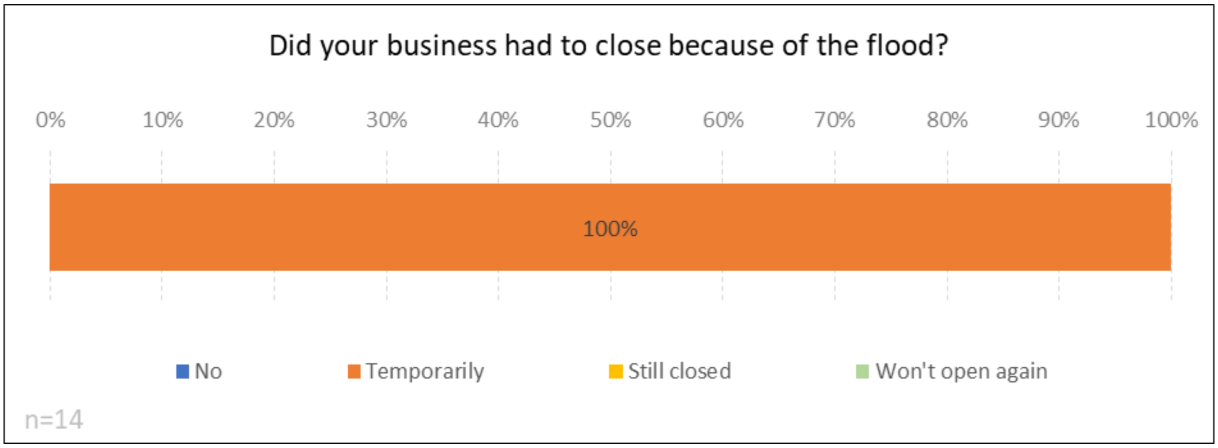



*Figure 130: Percentages of businesses that had to close (temporarily) or not because of the flood, Netherlands (questionnaire part 2 commercial, question 62).*

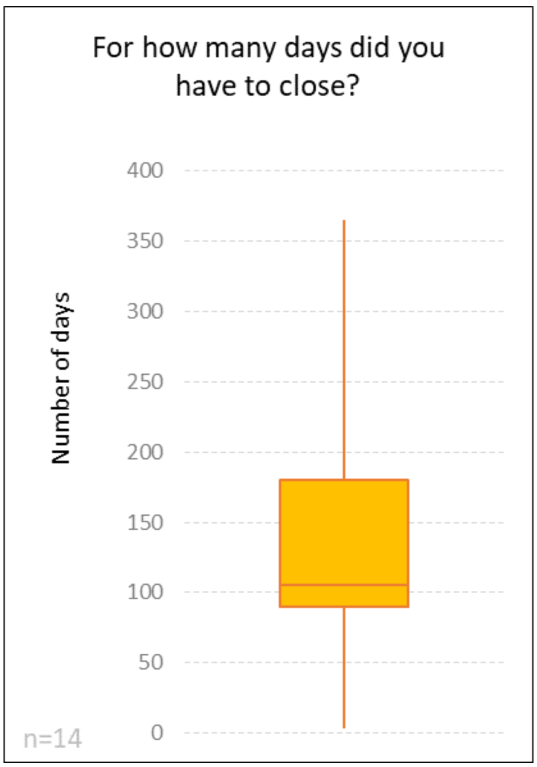



*Figure 131: Box plot of the number of days, businesses had to close because of the flood, Netherlands (questionnaire part 2, question 63).*

Of the commercial surveys, the majority had less than 10 FTE (Full-time equivalent) working at the company before the flood and this stayed the same after the flood, see Figure 267 and Figure 272. Two businesses had a higher number of FTE working, 25 and 87 FTE, which resulted after the flood in respectively 25 and 90 FTE. All mentioned that no employees were fired due to the flood and that the turnover after the flood was once open back to 100% or even higher, see Figure 268. Of the 14 participants, there were only two who mentioned not being fully recovered in terms of damage to the building after the flood. The others were either back to the state before or even improved, as can be seen in Figure 133. The period the businesses needed to recover is higher than the period the employees couldn't work, as can be seen in Figure 134 and Figure 270. Many mentioned that the employees started not long after the flood to help with cleaning. The period the employees could be paid is the same as the period of interrupted work of the employees. This means that all employees were continued to be paid despite being closed.

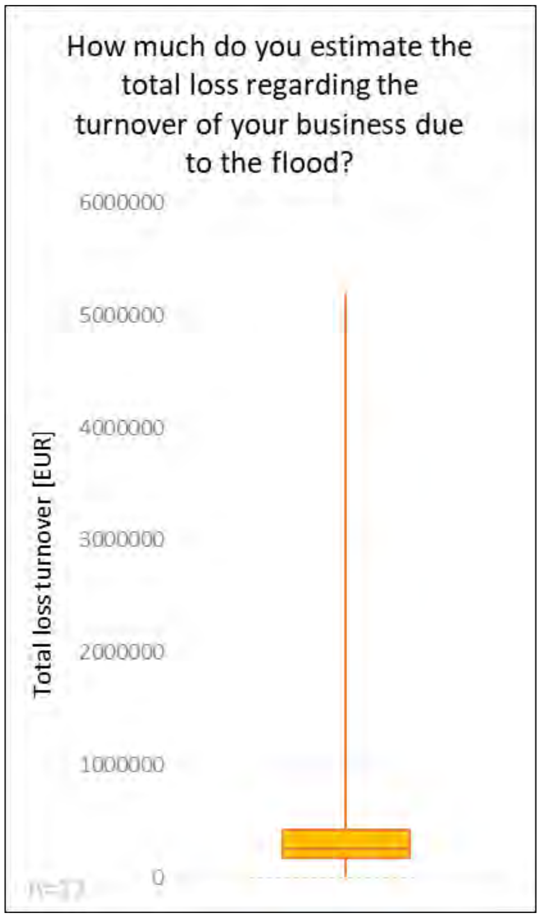



*Figure 132: Box plot of estimation of total loss regarding the turnover due to the flood, Netherlands (questionnaire part 2 commercial, question 67).*

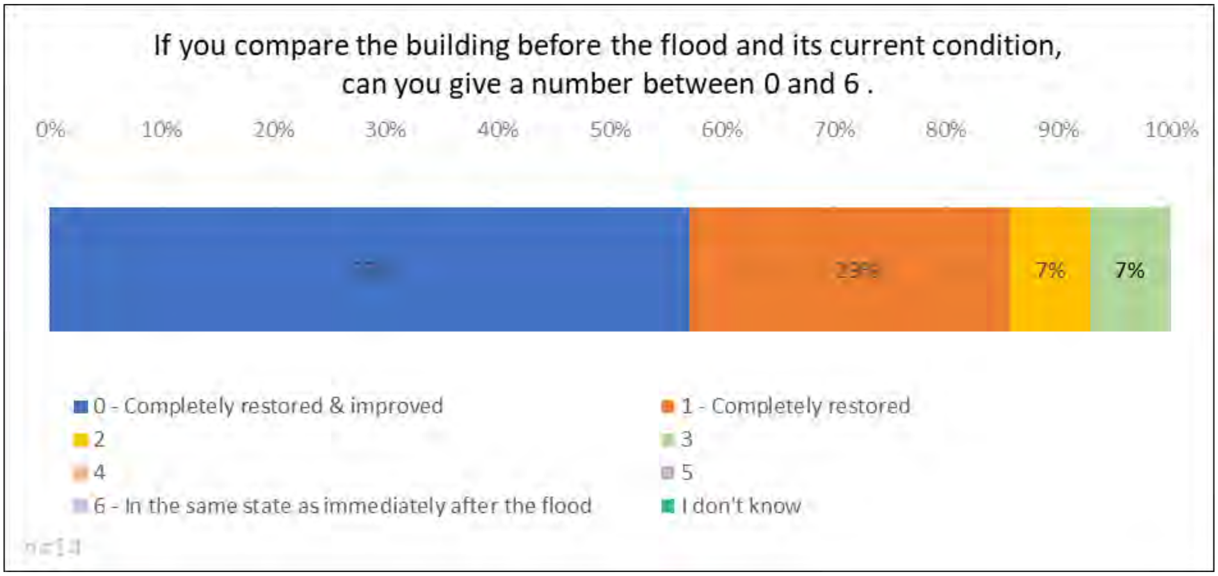



*Figure 133: Percentages of the assessment of the condition of the building, Netherlands (questionnaire part 2 commercial, question 70).*

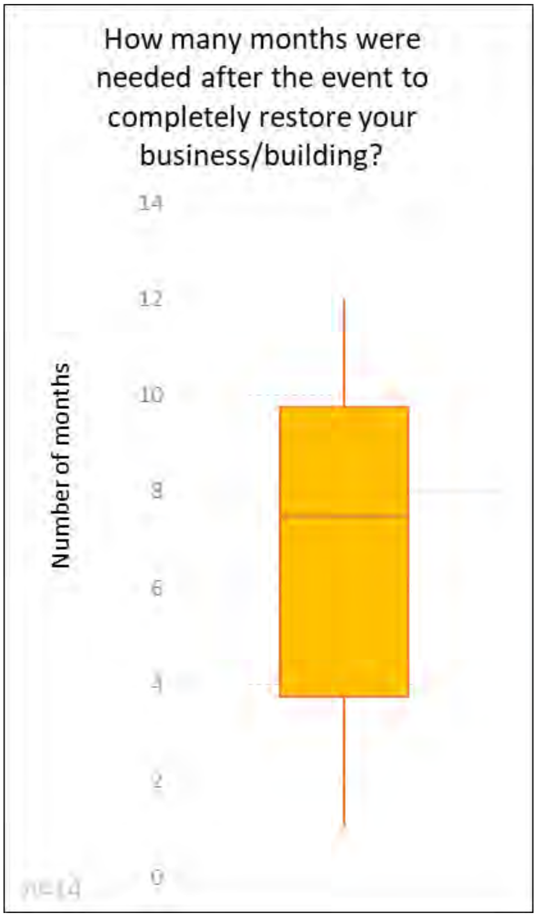



*Figure 134: Box plot of number of months to completely restore your business/building, Netherlands (questionnaire part 2 commercial, question 71).*

The financial compensation already received can be seen in Figure 135, where similar numbers as mentioned in the approved by the insurance company graph of Figure 264. Reasons for not getting all damage compensated varied but the most mentioned reasons were that parts were not fully covered by the insurance and that the profit loss was difficult to estimate (Figure 273).

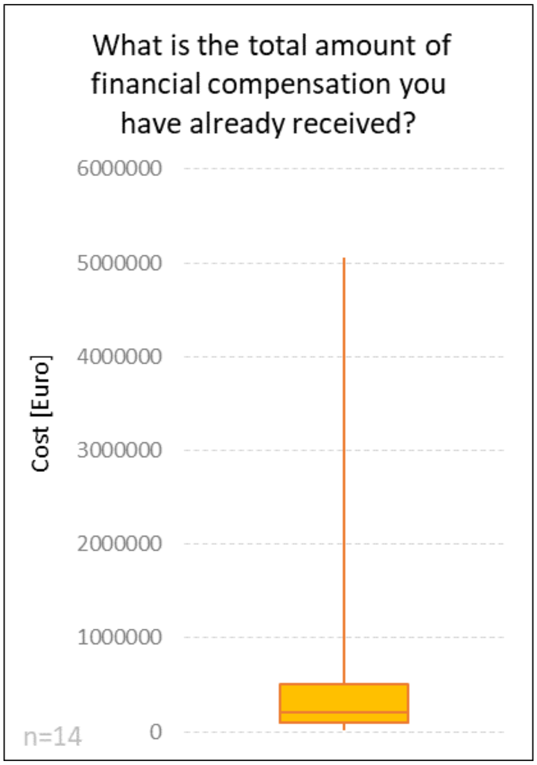



*Figure 135: Box plot of received financial compensation, Netherlands (questionnaire part 2 commercial, question 77).*


*Figure 136: Percentages of people who got a warning about the possibility of a flood or not and if yes, when, Netherlands (questionnaire part 2 commercial, question 82).*

Regarding warnings, none of the participants in the commercial sector received any warnings (Figure 136). The mentioned reasons for not implementing prevention measures were mainly that it was technically not possible and that such floods should not happen again. The graph of Figure 138 shows that 79% never experienced floods before (Figure 138). One-third of the participants in the commercial sector owned the building were the others rented the building for the business.

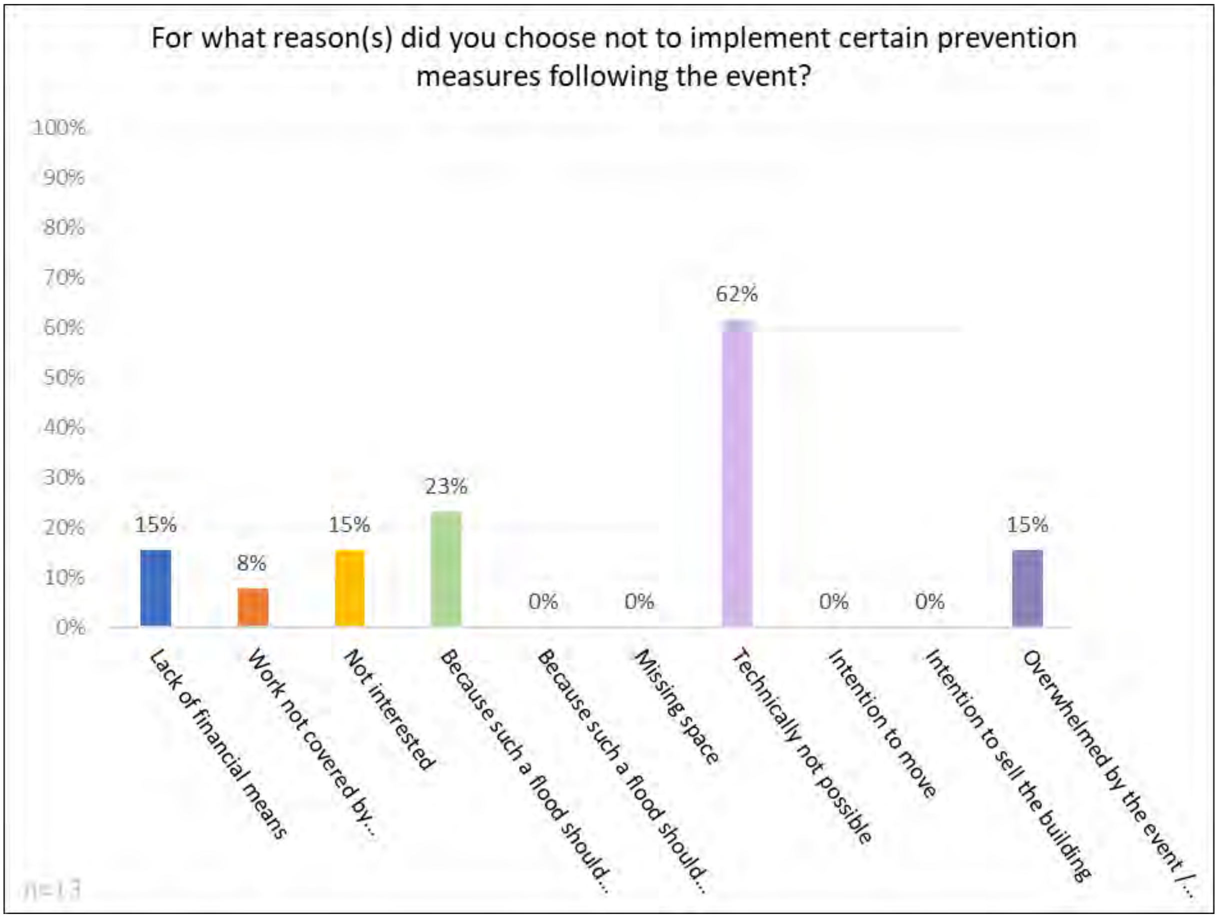



*Figure 137: Percentages of warning sources, from which the participants received a warning about the possible risk of flooding, Netherlands (questionnaire part 2 commercial, question 90).*

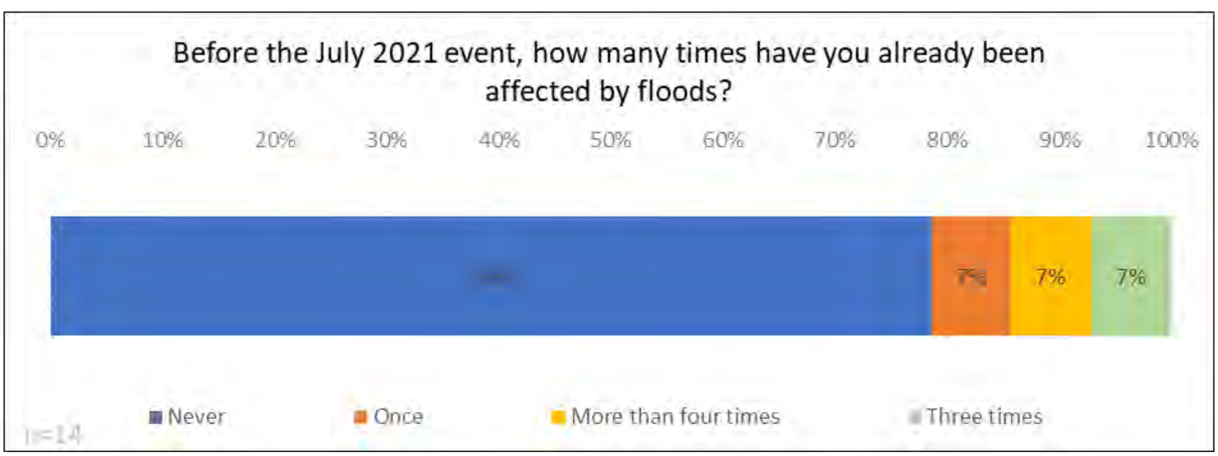



*Figure 138: Percentages of participants who were affected once or several times by a flood before the event in July 2021, Netherlands (questionnaire part 2 commercial, question 91).*

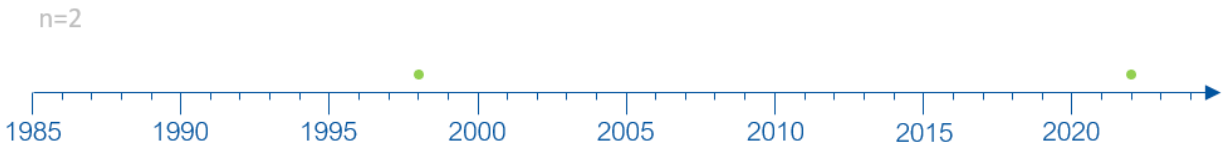



*Figure 139: Year of the last time when participants were affected by floods before, Netherlands (questionnaire part 2 commercial, question 92).*

## 4.4 International comparison

### 4.4.1 Vulnerability

The extent of flood damage is dependent on the vulnerability in the respective region as well as the hazard parameters. For the vulnerability, we looked at building characteristics as well as personal characteristics such as precautionary measures and behaviour.

In Germany (37%) and the Netherlands (40%) the percentages of detached houses are much bigger than in the surveyed area in Belgium (6%) and most houses (65%) in the considered region in Belgium were attached houses. In Germany most houses were built from natural stone on all levels. 73% of the buildings were built before the end of World War II and only 11% after 1970, none of them after 2010. In the Netherlands and Belgium natural stone was also a very common building method, but in both countries clay masonry occurred even more frequently. The age of the surveyed buildings in Belgium is very similar to that in Germany: 66% of the buildings were built before the end of World War II. In the Netherlands this is only 23% of the buildings. Most buildings from the Dutch interviews were built between 1946 and 1970 (65%). Regarding the last major renovation, in the surveyed areas in Belgium and Germany, many buildings had been renovated in the last 10 years before the flood, many even in the last 2 years before the flood. For the Netherlands, much fewer people gave a date for the last major renovation, but from the people who gave a value, nearly all had the last major renovation after 1995.

The most common heating system before the flood in July 2021 in all three countries was gas heating (BE = 82%, GE = 64%, NL = 95%). The most common place for the heating system in Germany and the Netherlands was the basement (53% each). In Germany many heating systems were located on the ground floor (25%) and in the Netherlands in the attic (24%). In Belgium on the other hand most heating systems were located on the ground floor (53%) and another 29% in the basement.

The warning situation in the Belgian survey area seems to have been much better than in the Dutch and German survey areas. In Belgium only 24% of the people did not receive any warning at all, whereas it was 78% in the Netherlands and 83% in Germany. It is important to stress that 65% of the Belgian respondents who received a warning and answered the question where they got the warning from, got a warning through their personal observations, which was the most common answer. The second most common answer was a warning from neighbours. The warnings from official sides were not better than in Germany or the Netherlands, but people seem to have been better prepared to interpret their personal observations correctly. Concerning efforts made by individuals to enhance their awareness and preparedness for potential floods, a higher percentage of people in Belgium benefit from an insurance coverage (96%) or consulted existing hazard maps before or during flood occurrences (71%). Notably, a mere 23% of the population in Belgium was registered with the warning system, but 97% expressed no intention to seek methods for safeguarding their homes in the event of future floods.

In contrast, both Germany and the Netherlands exhibited lower insurance coverage in the surveyed areas compared to Belgium, where insurance against flood damage is compulsory. Despite experiencing damages from the recent flood event, a substantial 62% of the Dutch population does not plan to obtain insurance. The inclination to explore ways to protect homes or investigate the positioning of buildings on hazard maps—indicators of flood risk awareness—is notably scarce in Germany and the Netherlands. In both countries, up to 50% of the population does not plan taking action nor seeking information in this regard.

### 4.4.2 Hazard

The maximum reported value for the maximum water depth outside the building was about 3 m in all countries, but it can be seen, that the median values for the surveyed areas in Belgium (1.7 m at the front door) and in Germany (1.5 m at the front door and 2.0 m at the most flooded point) were significantly higher than in the Netherlands (0.5 m at the front door and 1.0 m at the most flooded point). Regarding the maximum water depth in the basement there are little differences, because most people's basements were completely filled with water and basement heights do not vary much. As for the water depth on the ground floor the mean values for Germany and Belgium are higher than for the Netherlands by 0.6 m resp. 1.1 m. Only four people in Germany gave a water height of up to 1.5 m on the first floor. The basement was damaged in all cases where a basement was present. The ground floor was most frequently damaged in Belgium and less frequently in the Netherlands.

The intensity of the water flow was assessed to be higher in Germany and Belgium compared to the Netherlands. In Belgium and Germany, 64% and 75% of the surveyed people categorized the flow as torrential, and 71% in both instances believed that standing in the floodwater would lead to being swept away. Indeed, the photos and videos shared by the participants in both regions depicted flows with velocities that would make survival impossible if one were to enter the water. In contrast, only 28% of respondents in the Netherlands considered the flow as torrential, and just 14% believed it would be impossible to stand in the water due to its high velocity. Consequently, the lower water depth and velocities in the Netherlands resulted in a less hazardous situation compared to Belgium and Germany.

The most frequent reason for the flooding of the participants homes was the overflow of a watercourse in Germany and Belgium, whereas it was runoff in the Netherlands. Interestingly, in both Belgium and Germany, many people perceive that the failure or mismanagement of a hydraulic structure in the region as a reason for the flooding.

The comparison of hazard parameters in the regions of the three countries where interviews have been conducted shows that the maximum extent of the flood seems comparable in all three countries. However, in Germany and Belgium the mean values of water depth and flow velocity are higher than in the Netherlands. This is consistent with the mean values of water depth in the buildings and the number of affected floors. The primary factor leading to the flood, as reported by participants, is consistent across the three regions, with river overflow identified as the primary cause. Although mismanagement of dams was given as a potential reason in Germany and Belgium, no information could be found to verify these ideas.

### 4.4.3 Damage

Damage values have been divided into damage to household items and damage to the building.

Household items were mainly damaged directly by getting in contact with the water, sediments or by contamination. Notably, in all three regions, over 95% of reported cases involved mud, with Germany and the Netherlands also experiencing a substantial presence of sand and stones. Unlike Belgium and the Netherlands, Germany reported more than 50% of cases the presence of vegetation, garbage, rubble, and large objects, such as cars or significant parts of caravans in the flood water, potentially leading to additional damage in this region.

Regarding contamination, in Belgium and Germany, hydrocarbons were the main source of contaminated water, accounting for 44% and 54% respectively. On the other hand, residents in Netherlands more frequently reported sewage water and chemicals, in agreement with the predominant cause of damage reported in this region: runoff.

The most frequent items that need to be replaced are items that are usually stored in the basement like washing machines/dryers, refrigerators/freezers, boilers, tools, and other electrical appliances. It is noticeable, that in the Netherlands the shares of items that needed to be replaced were much smaller in general. The shares were the highest in Belgium. Compared to Germany, in Belgium the percentages of people who needed to replace items that are usually stored on the ground floor were higher. The biggest share of people who had one or several cars and motorcycles impacted can be found in Germany.

The median values regarding the cost of the damaged household contents are similar in all three countries (BE = 22,850 €, GER: 25,000 €, NL = 20,000 €). The number of participants who rated the status of their household condition as '1 – fully functional again' was highest in the Netherlands and the Dutch interviews were conducted latest and consequently the time for reparations was longer. But the time, participants whose household was fully recovered again at the time of the interview, gave for the household restoration was also the smallest in the Netherlands. The worst statutes of household condition appear amongst German participants.

The most common damages to the buildings were damages to the interior linings, the pavement, and the doors in all three countries with percentages all above 60%. For Germany (66%) and Belgium (46%) also damages to the windows and for the Netherlands damages regarding infiltration (44%) were very common. The most substantial damages like slight cracks/damage to the exterior building coating and collapses of construction elements were reported in Germany (27%). In the Netherlands 2% required building demolition. For Belgium, and Germany it is also known that some buildings collapsed or had to be demolished, but no interviews could be conducted with the people who lived in the houses at the time of the flood.

When looking at the total costs regarding the building damages, it can be seen that the minimum, median and maximum values are the lowest in the Netherlands and the highest in Germany. In Table 4 it can be seen that the differences are quite high. -The damages to the buildings reported were more severe in the Netherlands, regardless of the lower water levels and flow strengths, might be a hint for reasons of the damages are lying in the different characteristics of the buildings in the different countries, like the building method.

*Table 4 : Minimum, median, and maximum values fort the total costs regarding to the building damages in all three countries.*

| | **Minimum** | **Median** | **Maximum** |
|---|---|---|---|
| **Netherlands (n=50)** | 75 € | 30,000 € | 250,000 € |
| **Belgium (n=39)** | 750 € | 53,000 € | 250,000 € |
| **Germany (n=53)** | 2,500 € | 125,000 € | 650,000 € |

Regarding the building damages costs, the financial compensation that was approved by the insurance also was the lowest in the Netherlands and the highest for Germany.

### 4.4.4 Survey strategy

The survey strategy of in-person interviews was specifically chosen to allow personal interaction between interviewees and researchers, with the hope of gaining more detailed and reliable information than from a phone or online survey. The shortest interviews lasted about 20 min, but most interviews lasted much longer, as revealed by the very similar median duration of the interviews in all three countries (43 min – 58 min). An interview duration of about 20 minutes could only be reached, when people answered the questions straight-to-the-point, without telling stories besides the answers to the questions. Based on the experience of the survey teams, many people had a great need to talk, especially older people who seemed to have scarcely talked to anyone about the event. Also, it seems like some people saw the survey team as officials and hoped their critics would be heard and taken into account for deciding future flood protection.

A downside to in-person interviews during working hours is the overrepresentation of retired people. Regarding the socio-professional category, the results show that retired people are overrepresented in the study, with 64% in Belgium and 44% in Germany. In the Netherlands retired people present a share of 29% of participants. The surveys were indeed conducted during usual working hours, from Monday to Friday between 8 AM and 6 PM. Although the age of participants was not recorded in the study, the overrepresentation of retired persons indicates that the groups of participants do not represent the age distribution of the affected population in the surveyed areas. However, this only has a possible effect on the characterization of vulnerability parameters regarding precautionary measures and behaviour. Building characteristics and hazard parameters are not affected by this.

### 4.4.5 Commercial sector

The Dutch interviews in the commercial sector were mainly conducted in the service industry. Indeed, before the flood, the affected area comprised many restaurants (indoor and outdoor) and hotels/guest rooms, but also workshop, shops, offices, and other services. In 93% of the cases, the premises were not usable again. Like in the residential sector, most basements and ground floors were affected, and none of the businesses had damages on the first floor nor higher. Interestingly, in the commercial sector, three times more contaminations with hydrocarbons were reported than in the residential sector. Items the businesses needed to replace were mainly machinery, furniture, tools, electrical equipment, and sales goods. Most businesses had no vehicles impacted. The total costs of the damaged sales goods lie between 4,000 € and 700,000 €, with a median value of about 100,000 €, which is considerably higher than the losses for the damaged household items in the Netherlands. Reported losses for the damaged equipment range between 20,000 € and 700,000 €. At the time of the interview, 86% of the businesses had completely restored their business items, which took between two and twelve months. The age of the buildings where the businesses are located is generally much higher than for the Dutch residential sector. Like in the residential sector, no oil heating systems were observed in the Dutch businesses. The most common location of the heating was the attic. The types of building damages are similar to the Dutch residential sector. The highest losses related to the building damages in the study occurred in the commercial sector with 1,600,000 €. Consequently, the financial building damages approved by the insurance were also higher than in the residential sector. All interviewed businesses faced downtime because of the flood, mostly because of the reconstruction, but none had to close completely or was still closed at the time of the interviews. The time until a full recovery was higher for the business sector than in the Dutch residential sector. The estimated total loss regarding the turnover ranges between 0 € and 5,200,000 € with a median value of 250,000 €. The turnover at the time of the interview is at least the same as before the flood for all surveyed businesses. For the employees, the work was interrupted between 0 and 270 days with a median value of 90 days. The maximum compensation that a business received in the surveyed area was up to 5,055,000 €.

# 5 Conclusion and prospects

In mid-July 2021, parts of Germany, Belgium and the Netherlands were hit by persistent heavy rainfall, which led to devastating floods which claimed over 200 lives, injured hundreds of people and damaged, sometimes even destroyed, the homes of several thousands of people as well as damaged the infrastructures in the affected areas.

The Interreg project EMFloodResilience aims to ensure that flood management in the Euregio Meuse-Rhine is improved across borders in order to dampen flood waves in the future and reduce the amount of induced damages.

As part of this project, Deliverable 5.1.2 consists in data collection through a field survey among the affected population. The results of this survey were presented and discussed. The main objective of this data collection is to use the data in Deliverable 5.1.3 of the same work package. However, insights could also be drawn from the data itself.

The results of the survey show that the vulnerability in the three countries was different regarding people's preparedness as well as building characteristics. The reported water levels and flow strengths at the participants homes were in general higher in Germany and Belgium than in the Netherlands.

However, the reported damage did not differ significantly between the three countries. These results show that the prediction of flood damage is difficult even for the same event as soon as different areas (and countries) are hit. This brings up the question of whether existing flood damage models are up to the task of robustly predicting flood damage.

In the course of the project, insights on how to better conduct a similar study have repeatedly emerged. Therefore, some recommendations for future studies are outlined here.

- In the course of the surveys, it was found that some questions are so detailed that hardly anyone can answer them and other questions come up in the course of the interviews that are not included in the questionnaire. The recommendation is therefore to conduct more test interviews during the questionnaire preparation phase.
- The questions are sometimes interpreted differently by different interviewees, which inevitably affects the quality of the results. It is therefore recommended that all questions be formulated as clearly as possible. In the case of this cross-border survey, an additional risk of misinterpretation arises from the translations of the questionnaires in a total of four languages (English, French,

Dutch and German). Not only small errors may occur during the translation itself, but it is also in the nature of different cultures to express similar ideas slightly differently, which means that not everything can be translated word-by-word, and the translation opens up room for interpretation.

- Another recommendation from the experience of this study is to use 10 minutes for follow-up after each interview in order to leave notes that may have been written down in a hurry clearly and completely for digitalization.
- Many participants are traumatized by the event and were very emotional during the interviews. A strong recommendation is to professionally train survey teams in handling traumatized people. Overall, it may be useful to design guidelines for population surveys of this kind. This could improve the quality of future studies from the outset.

Due to the survey days and times, a substantial proportion of the respondents are retired and hence the survey group does not fully represent the population of affected people in the survey areas, regarding the socio-professional category and age.

Compared to other studies which were conducted online, the data set of this survey is smaller, with 70 to 72 surveys in each country and 212 surveys in total. To compensate this, the double digitalization and the on-site verifications performed by the interviewers ensure a high quality of the available data.

However, not all questions were answered by all participants, so that some questions contain fewer than 70 data entries. A limited number of people were able to provide precise numbers regarding the monetary losses of individual items.

The main purpose of collecting the presented data was to generate flood damage data for the assessment and improvement of damage models. This is performed in deliverable 5.1.3, which builds upon this deliverable. The presented data covering various dimensions of risk can be used in numerous ways to improve flood management, both in the studied areas and in general. Not only can the data be used to improve the understanding of how flood induced damages arise, but also to improve the understanding of the nature of floods themselves. For example, the comparatively large data set of water level data can be used to create large-scale water level maps. Together with the collected information about times of water arrival and leaving it and the recorded locations it can be used to validate numerical models for the flood event in July 2021. In addition, statistical hypothesis tests can uncover correlations and hence be used to determine which parameters influence the damage caused and to what extent. Additionally, the qualitative statements collected from the affected people about current needs and improvements will be valuable for improving future flood management, because it gives scientists and officials a new point of view that can only be gained by experiencing a flood.

# References


Bezirksregierung Köln (2021): Hochwasserrisikomanagementplan für das nordrhein-westfälische Einzugsgebiet der Maas für den Zeitraum 2021 bis 2027. Unter Mitarbeit von Gertrud Schaffeldt, Katharina Ducke und Kerstin Menn. Bezirksregierung Köln. Köln. Online verfügbar unter https://www.flussgebiete.nrw.de/die-hochwasserrisikomanagementplaene-fuer-nrw-5777, zuletzt geprüft am 20.04.2023.

CEDIM (2021): Hochwasser Mitteleuropa, Juli 2021 (Deutschland) : 21. Juli 2021 – Bericht Nr. 1 „Nordrhein-Westfalen & Rheinland-Pfalz". Unter Mitarbeit von Andreas Schäfer, Bernhard Mühr, James Daniell, Uwe Ehret, Florian Ehmele, Katharina Küpfer et al. Center for Disaster Management and Risk Reduction Technology (CEDIM), Karlsruher Institut für Technologie (KIT).

Deutsches Zentrum für Luft- und Raumfahrt (DLR): Aktuelle Wetterbilder.

ENDENDIJK ET AL. (2023): Experience From the 2021 Floods in the Netherlands: Household Survey Results on Impacts and Responses.

enw (Hg.) (2021): Hoogwater 2021 Feiten en Duiding. Expertise Netwerk Waterveiligheid (enw).

FB 51 - Landesamt für Natur, Umwelt und Verbraucherschutz Nordrhein-Westfalen (LANUV NRW): Personal information.

HEIDENREICH (2023): Wie erlebten Betroffene die Warnsituation vor den Starkregen- und Hochwasserereignissen Mitte Juli 2021? Steckbrieg für den Landkreis StädteRegion Aachen. Unter Mitarbeit von Anna Heidenreich. Institut für Umweltwissenschaften und Geographie, Universtität Potsdam (Förderkennzeichen: 13N16230).

IMC (Hg.) (2022): River Basin Management Plan for the International Meuse River Basin District, 3rd cycle of the Water Framework Directive. (2022-2027). International Meuse Commission, zuletzt geprüft am 20.10.2023.

IT.NRW: ELWAS-WEB. Ministerium für Umwelt, Naturschutz und Verkehr des Landes Nordrhein-Westfalen. Online verfügbar unter https://www.elwasweb.nrw.de/elwas-web/index.xhtml, zuletzt geprüft am 23.06.2023.

Junghänel et al. (2021): Hydro-klimatologische Einordnung der Stark- und Dauerniederschläge in Teilen Deutschlands im Zusammenhang mit dem Tiefdruckgebiet „Bernd" vom 12. bis 19. Juli 2021. Hg. v. Deutscher Wetterdienst. Deutscher Wetterdienst.

Kupferstadt Stolberg (Hg.) (2023): Altersstruktur. Unter Mitarbeit von Iris Jansen. Bürgerservide Stolberg.

MOHR ET AL. (2023): A multi-disciplinary analysis of the exceptional flood event of July 2021 in central Europe – Part 1: Event description and analysis. In: *Nat. Hazards Earth Syst. Sci.* 23 (2), S. 525–551. DOI: 10.5194/nhess-23-525-2023.

MULNV NRW (2021): Steckbriefe der Planungseinheiten in den nordrhein-westfälischen Anteilen von Rhein, Wester, Ems und Maas. Bewirtschaftungszeitraum 2022-2027. Oberflächengewässer und Grundwasser Teileinzugsgebiet Maas/Maas Süd NRW. Hg. v. MULNV NRW. Ministerium für Umwelt, Landwirtschaft, Natur- und Verbraucherschutz des Landes Nordrhein-Westfalen (MULNV NRW). Online verfügbar unter https://www.flussgebiete.nrw.de/planungseinheiten-steckbriefe-2022-2027-8444, zuletzt geprüft am 23.06.2023.

Munich Re (2022): Hurricanes, cold waves, tornadoes: Weather disasters in USA dominate natural disaster losses in 2021 – Europe: Extreme flash floods with record losses. Hg. v. Media Munich Re. Online verfügbar unter https://www.munichre.com/en/company/media-relations/media-information-and-corporate-news/media-information/2022/natural-disaster-losses-2021.html, zuletzt geprüft am 21.06.2023.

NOS Nieuws (2021): 400 miljoen euro schade door overstroming Valkenburg, 2300 huizen beschadigd. In: *Nederlandse Omroep Stichting (NOS)*, 21.07.2021. Online verfügbar unter https://nos.nl/artikel/2390198-400-miljoen-euro-schade-door-overstroming-valkenburg-2300-huizen-beschadigd, zuletzt geprüft am 01.05.2023.

SCHÜTTRUMPF (2021): Das Juli-Hochwasser 2021 in NRW - Ein erster Erfahrungsbericht. In: *Wasser Abfall* 23 (7-8), S. 14–17. DOI: 10.1007/s35152-021-0665-7.

Stadt Eschweiler (Hg.) (2023): Staitstischer Jahresbericht der Stadt Eschweiler. 2020. Online verfügbar unter https://www.eschweiler.de/stadt-rathaus/eschweiler-in-zahlen-fakten/jahresberichte/statistischer-jahresbericht-2020.pdf?cid=8dt, zuletzt geprüft am 25.10.2023.

THIEKEN ET AL. (2023): Performance of the flood warning system in Germany in July 2021 - insights from affected residents. In: *Nat. Hazards Earth Syst. Sci.* 23 (2), S. 973–990. DOI: 10.5194/nhess-23-973-2023.

VAN HEERINGEN ET AL. (2022): Analyse overstroming Valkenburg. Watersysteemevaluatie Waterschap Limburg. Deltares. Online verfügbar unter https://publications.deltares.nl/11207700_000_0014.pdf, zuletzt geprüft am 22.06.2023.

WVER (2021): WVER und IWW erhalten Förderbescheid zur wissenschaftlichen Begleitung des Wiederaufbaus in den Hochwassergebieten in NRW und Rheinland-Pfalz. Wasserverband Eifel-Ruhr (WVER).

CSR. (2022). 1 an après les inondations … Bilan de la gestion post-inondations et continuité de la reconstruction. Commissariat Spécial à la Reconstruction. https://www.wallonie.be/sites/default/files/2022-07/Bilan%20complet%20CSR%2026%20juillet%202022.pdf

Dewals, B., Erpicum, S., Pirotton, M., & Archambeau, P. (2021). July 2021 extreme floods in the Belgian part of the Meuse basin. University of Liege.

Poussard, C., Dewals, B., Archambeau, P., & Teller, J. (2021). Environmental Inequalities in Flood Exposure: A Matter of Scale. Frontiers in Water, 3, 633046. https://doi.org/10.3389/frwa.2021.633046

# Appendix

## A – Questionnaires

### Part 1

**Damage modelling – Field survey – part 1: personal information**

1. Country

2. Municipality

3. Postcode

4. Address: street name, house number, box number (optional)

5. Coordinates (longitude)

6. Coordinates (latitude)

7. Interview date

8. Does the target decide to participate in the study?
   - ☐ Yes
   - ☐ No → Q n°9

9. Why the target does not want to participate?
   - ☐ No advantage to answer
   - ☐ Not available
   - ☐ Traumatized by the event
   - ☐ Language barrier
   - ☐ Not interested
   - ☐ Covid-19 quarantine
   - ☐ Not impacted

10. What is your level of education?
    - ☐ Elementary school
    - ☐ High school → Q n°11
    - ☐ Bachelor
    - ☐ Master or more

11. Please precise the level (<u>Only for Germany</u>):
    - ☐ Hauptschulabschluss/Berufsbildungsreife
    - ☐ Realschulabschluss/Fachoberschulreife
    - ☐ Abitur/Fachabitur

12. What socio-professional category describes best your situation?
    - ☐ Employee (FR: *salarié*), as a manual worker (FR: *ouvrier*)
    - ☐ Employee (FR: *salarié*), as an office worker (FR: *employé*)
    - ☐ Self-employed (FR: *indépendant*), as a manual worker (FR: *ouvrier*),
    - ☐ Self-employed (FR: *indépendant*), as an office worker (FR: *employé*)
    - ☐ Retired
    - ☐ Unemployed (short term: less than a year)
    - ☐ Unemployed (long term: more than a year)
    - ☐ Student
    - ☐ Other → Q n°13
    - ☐ I don't know

13. Other socio-professional category:

| |
|---|
| |

14. Would you like to be kept informed of the progress of the study?
    - ☐ Yes
    - ☐ No

15. Mean of contact (e-mail, phone n°…)

| |
|---|
| |

16. Upload photo(s) of the building

## Part 2 residential

### Damage modelling (residential) – Field survey – PART 2: RESEARCH INFORMATION

*Please leave the question in blank if you don't know the answer and enter 0 just when the answer is 0.*

1. Interview start time

| |
|---|
| |

2. Type of interview?
   - ☐ Field (preferred)
   - ☐ Phone

3. Water depth, time and date in the different building levels:

| | Outside the building (front door) | Outside the building (most flooded point) | Basement | Ground floor | First floor |
|---|---|---|---|---|---|
| Maximum water depth reached [m] | | | | | |
| Date and time of **water arrival** | | | | | |
| Date and time of **maximum water depth** | | | | | |
| Date and time of **water leaving the building** | | | | | |

4. Are you a **tenant** or **owner** of the accommodation?
   *[Note: Co-owners are considered owners (example: co-ownership of a married couple, homeowners, associations, etc.]*
   - ☐ I am a tenant
   - ☐ I own the housing unit (e.g., a flat in an apartment block)
   - ☐ I own the whole building

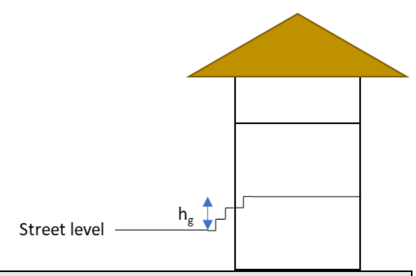
5. To what do you attribute **the flooding of your home**?
   *[Note: multiple answers possible!]*
   - ☐ Runoff (for example, rainwater flowing down uncontrolled on the road or on neighbouring land)
   - ☐ Overflow of a watercourse (for example, a stream or a river having overflowed its bed)
   - ☐ Saturation of the sewage system, which could no longer take water from the roads
   - ☐ Water has directly entered the rooms below street level (e.g., backflow through drains, toi-lets, showers, or sewage system)
   - ☐ Lack of drainage on the property (overflowing depressions in the garden, overflowing man-holes, failing drainage of the gutters)
   - ☐ Failure of a dike or dam / failure of a flood retention basin
   - ☐ Groundwater flood (rise of groundwater)
   - ☐ I don't know
   - ☐ Other cause of flooding → Q n°6

6. Other cause of flooding:

| |
|---|
| |

7. What do you think: Could an **average person have been able to stand effortless in the flooded street** in the immediate vicinity of your house, would (s)he has had to **make efforts to stay upright** or would (s)he have been **swept away**?
*[Note: At the most dangerous moment, i.e., the moment of the highest flow velocity]*
   - ☐ *Could have easily stood*
   - ☐ *Should have made efforts to stay upright*
   - ☐ *Would have been swept away by the current*
   - ☐ *The water was too deep to stand*
   - ☐ *I don't know*

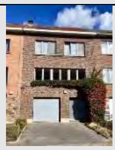
8. How high do you have to **climb to reach the ground floor from the street level** (sidewalk)? **[*to be measured (ex: 0.30 m)*]**
   *[Note: This corresponds to steps, located both outside and inside, which you must climb from street level to reach the ground floor; it's not about the steps you have to climb from the basement to reach the ground floor. Indicate the value in **meters**].*




| |
|---|
| |

9. At **what level(s)**, including the basement, was the residential **building damaged**?
   *[Note: Please mark ALL relevant levels!]*
   - ☐ Basement
   - ☐ Ground floor
   - ☐ 1st floor
   - ☐ 2nd floor
   - ☐ 3rd floor
   - ☐ 4th floor
   - ☐ Attic
   - ☐ No damage in any level
   - ☐ I don't know

10. Are the following levels finished in the building?
    *[Note: Before the floods. Finished means with plaster, painting or any additional covering material in the walls and floor]*

| | **Yes** (even if partially finished) | **No** (e.g., garage, storage area …) |
|---|---|---|
| Basement | | |
| Ground floor | |  (sample photograph) |

*11.* Which of the **following materials** were **transported** or **deposited by water** in the building or in direct contact with it?
*[Note: Please read and mark as appropriate!]*
- ☐ Mud
- ☐ Sand/stone
- ☐ Vegetation (wooden logs, branches, roots)
- ☐ Garbage
- ☐ Rubble (material from demolished buildings or structures upstream)
- ☐ Large objects (e.g., tanks, cars, containers, interlocked objects)
- ☐ None
- ☐ I don't know

12. From the previous materials transported by water, could you estimate their **maximum size**?
*[Note: Please enter the estimated length [m]]*

| |
|---|
| |

13. How **strong was the water flow** in the immediate vicinity of your house? Please give me a number between 1 for “calm flow”; and 6 for “torrential”. You can use the intermediate values to score your answer.
*[Note: only one answer possible!]*
- ☐ *1 - Calm flow*
- ☐ *2*
- ☐ *3*
- ☐ *4*
- ☐ *5*
- ☐ *- Torrential flow*

14. Has your home been **contaminated by any of the following substances**?
*[Note: read and mark as appropriate. Several possible responses!]*
- ☐ *Chemicals, paints, varnishes, pesticides, small amounts of motor oil*
- ☐ *Sewage or faeces*
- ☐ *Hydrocarbons (fuel, fuel oil, etc.)*
- ☐ *No, no pollution due to these substances*
- ☐ *I don't know*

15. What is the **surface** of your **ground floor**?
*[Note: Enter the area in square meters. If necessary, ask for a rough estimate.]*

| |
|---|
| |

16. Which of the **following items** did you need to **replace**?
*[Note: Please read aloud, multiple answers are possible].*
- ☐ Washing machine; dryer
- ☐ Refrigerator; Freezer
- ☐ Boiler
- ☐ Pellet stove
- ☐ Stove / Oven
- ☐ Dishwasher
- ☐ Television, stereo
- ☐ Computer / Laptop
- ☐ Equipped kitchen
- ☐ Telephone system
- ☐ Living room furniture
- ☐ Furniture for children's bedroom(s)
- ☐ Furniture for bedroom(s), guest room
- ☐ Leisure accessories
- ☐ Tools
- ☐ Other electrical appliances
- ☐ Bathroom furniture
- ☐ Personal objects such as clothing,
- ☐ Antiques and art works
- ☐ Other voluminous and/or expensive items
- ☐ No, no valuable object
- ☐ I don’t know

17. Which other voluminous and expensive items?

| |
|---|
| |

18. Have you had a car or motorcycle impacted by the flood? If yes, how many?

- Car : __________
- Motorcycle : __________

19. How much do you estimate the **total cost** of **replacing** your **damaged household contents**?
*[Note: Make sure the amount is in EURO! Important: This is the total amount for all damaged items!]*

| |
|---|
| |

20. What is this **value based on**?
- ☐ Receipts and invoices
- ☐ Expert advice for damage compensation, for example through insurance or financial assistance
- ☐ Own estimate
- ☐ Other document(s) used → Q n°21

21. Other document(s) used:

| |
|---|
| |

22. Is this estimation including the replacement of all the damaged items or are you still missing some that are not included in the cost you previously mentioned?
- ☐ Yes, all the damaged items are included.
- ☐ No, there are damaged items that have not been replaced.

23. Is the compensation procedure with the insurance company over, so the amount for damaged items' compensation of is already defined, or is the process with the insurance company still ongoing and the amount of damaged items to be refunded can change?
- ☐ Yes, the compensation is over. The damage cost for household content is fixed.
- ☐ No, there compensation is still ongoing. The damage cost for household content could change.

24. Have you completely replaced the damaged household items or do they still show obvious defects and gaps as a result of the flood?
*Please give me a number between 1 for "I have completely replaced all affected household items since then" and 6 for "Household items still have significant gaps and defects". You can use the intermediate values to score your answer.*
- ☐ 1 - Fully functional
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6 - Household items still have significant defects or shortcomings
- ☐ I don't know

25. How many months after the event did it take you to fully recover (repair or replace) your personal household effects?

| |
|---|
| |

26. Which **description** matches best the building?
    - ☐ Detached house (four facades)
    - ☐ Semi-detached house (three facades)
    - ☐ Attached (two facades)
    - ☐ Appartement block
    - ☐ Other → Q n°27

27. Other description of your house:

| |
|---|
| |

28. How many **levels** does the building have **in total**, including basement, ground floor, and attic?
*[Note: Include the attic, even if it is not finished!]*

| |
|---|
| |

29. What is the **construction method** of the different building levels?
[*Note: Multiple answers possible (for mixed construction methods). We must answer to this question only when we have a piece of evidence, or we fully trust the knowledge of the person. Otherwise, we must tick "I don't know"]*

| | **Basement** | **Ground floor** | **Upper floors** |
|---|---|---|---|
| Reinforced concrete | | | |
| Timber frame | | | |
| Concrete masonry | | | |
| Clay masonry | | | |
| Prefabricated | | | |
| Natural stone | | | |
| Cavity walls | | | |
| Half-timbered building (FR: Colombage, DE: Fachwerkhaus, NL: Vakwerkhuis) | | | |
| I don't know | | | |
| Other method → Q n°0 | | | |

30. Other construction method(s):

| | Basement | Ground floor | Upper floors |
|---|---|---|---|
| Other method | | | |

31. How were the **flooded basement rooms used** BEFORE the July 2021 flood?
*[Note: Do not read aloud! Mark as appropriate, multiple answers are possible*

- ☐ Basement apartment
- ☐ Storage room
- ☐ Boiler room, technical installations
- ☐ Place for the domestic fuel tank
- ☐ Sauna
- ☐ Work room, recreation room
- ☐ Laundry
- ☐ Drying room
- ☐ Living room (example: bedroom, children's room, guest room)
- ☐ Office
- ☐ Commercial shop
- ☐ Bicycle cellar
- ☐ Fitness room
- ☐ Kitchen
- ☐ Party room
- ☐ Storage room (wine cellar, food, etc.)
- ☐ Underground parking, garage
- ☐ Crawl space (used only for building maintenance)
- ☐ No use
- ☐ Other use(s) → Q n°⍰

32. Other use(s):

| |
|---|
| |

33. Can you tell me approximately when the building was built?

- ☐ Before 1875
- ☐ 1875-1918
- ☐ 1919-1945
- ☐ 1946-1970
- ☐ 1971-1990
- ☐ 1991-2000
- ☐ 2001-2010
- ☐ After 2011

34. Has the building undergone a major renovation? If so, when was the last time?
*[Note: Write down the year, only "major renovations" as the replacement of the soil, walls or isolation are meant.]*

| |
|---|
| |

35. What is the **heating system** of the accommodation?
[*Note: multiple answers are possible.*]

- ☐ Coal heating
- ☐ Gas heating
- ☐ Oil heating
- ☐ Electric heating or night storage
- ☐ District heating
- ☐ Pellet or wood chip heating, wood heating
- ☐ Air-source heat pump
- ☐ Ground source heat pump
- ☐ Other heating system(s) → Q n°36

36. Other heating system(s):

| |
|---|
| |

37. At what level was the heating system at the time of the disaster?

- ☐ Basement
- ☐ Ground floor
- ☐ 1st floor
- ☐ 2nd floor
- ☐ 3rd floor
- ☐ 4th floor
- ☐ 5th floor
- ☐ Attic
- ☐ Each level, each apartment
- ☐ Dependency outside the home (annex)
- ☐ Other place where the heating system was
- ☐ I don't know

38. Other place where the heating system was?

| |
|---|
| |

39. How much do you estimate the **total cost** of repairing the **heating system**?
*[Note: Make sure the amount is in EURO!]*

| |
|---|
| |

40. How much do you estimate the **total cost** of repairing the **electrical system**?
*[Note: Make sure the amount is in EURO!]*

| |
|---|
| |

41. How much do you estimate the **total cost** of repairing the **plumbing and sanitation system**?
*[Note: Make sure the amount is in EURO!]*

| |
|---|
| |

42. How much do you estimate the **total cost** of the **damaged systems**?
[*Note: Make sure that the amount is indicated in EURO!]*

| |
|---|
| |

43. What is included in the **total cost** of the **damaged systems**?
   - ☐ Heating system
   - ☐ Electrical system
   - ☐ Plumbing and sanitation system

44. Please describe the **building damage** in more detail using the following list.
*[Note: Please read the text! Many possible responses!]*

- ☐ Moisture infiltration only
- ☐ Wooden structure: expansion / contraction
- ☐ Slight cracks, damage to the exterior coating of the building (masonry, plaster) [structural and non-structural damage]
- ☐ Damage to interior linings
- ☐ Damage to the pavement (Floor covering material)
- ☐ Damage to doors
- ☐ Damage to windows
- ☐ Significant cracks or settlements, or deformations of walls and ceilings
- ☐ Collapse of construction elements (walls, ceilings)
- ☐ Building collapse
- ☐ Demolition required
- ☐ I don't know

45. What is the approximate **damage cost** related to the **replacement of the interior lining** (plaster, tiles on the wall, etc.)?
*[Note: Make sure the amount is in EURO!]*

| |
|---|
| |

46. What is the **approximate cost** of **damage to windows**?
*[Note: Make sure the amount is in EURO!]*

| |
|---|
| |

47. What is the **approximate cost** of **damage to doors**?
*[Note: Make sure the amount is in EURO!]*

| |
|---|
| |

48. If you cannot estimate the individual costs of damage to windows and doors, could you estimate the **total cost** of damage of **windows and doors**?
*[Note: Make sure the amount is in EURO!]*

| |
|---|
| |

49. To what do you primarily **attribute the damage to the building**?
*[Note: please read the text! Several possible responses!]*
- ☐ Water level
- ☐ Flow velocity
- ☐ Mud and sediment deposits
- ☐ Impacts of floating objects (tree trunks, debris, washed away vehicles, etc.)
- ☐ Water pressure
- ☐ Flood duration
- ☐ I don't know

50. If you **add up the costs** (material and labour) of **all necessary reparation work** on and in the **building**, what was **the total amount of damage to the building**?
*[Note: give the estimate that seems most likely to you in EURO. If asked: this also includes rental costs for equipment such as dehumidifiers, space heaters, etc. Important: The total amount of ALL damage is meant!]*

| |
|---|
| |

51. What is this **value based on**?
- ☐ Invoices for work carried out
- ☐ Trades quotes
- ☐ Expert estimate, for example from the insurance company
- ☐ Personal estimation
- ☐ Other source(s) → Q°52

52. Other source(s):

| |
|---|
| |

53. Is this estimation including the reparation of all damages in the building or are you still missing some works to do that are not included in the cost you previously mentioned?
- ☐ Yes, all the damages are included.
- ☐ No, there are damages that are still missing.

54. Is the compensation procedure with the insurance company over, so the amount of damage for the compensation is already defined, or is the process with the insurance company still ongoing and the amount of damage to be refunded can change?
- ☐ Yes, the compensation is over. The damage cost is fixed.
- ☐ No, the compensation is still ongoing. The damage cost could change.

55. For waste disposal, how many **hours of cleaning** did you report to insurance?
[*Note: Unit = Hour*]

| |
|---|
| |

56. What **compensation** did you receive **from the insurance** company for the **cleaning hours**?
[*Note : in euro*]

57. How much did it cost you to buy or rent **equipment related to the dehumidification** of your house after the floods (dehumidifier, heat gun...)?
[*Note: in euro*]

58. If your home was contaminated by hydrocarbons, how much did it cost you **to decontaminate it**?
[*Note: in euro*]

59. Can you indicate the **total amount** of the costs related to the **cleaning of the building** (waste disposal, dehumidification, decontamination)?
*[Note: in euros.]*

60. What is included in the **total cost** of the **cleaning of the building**?
- ☐ Waste disposal
- ☐ Dehumidification
- ☐ Decontamination

61. What is the **amount of damage** approved by the **insurance company**?
*[Note: Make sure the amount is stated in EURO! On request: only the insurance for damage to or in the house is concerned; the car insurance should not be taken into account! If zero euros were declared, write down zero]*.

62. Did you have to leave your apartment or house because of the damage?
- ☐ Yes
- ☐ No

63. How many days did you leave your accommodation?

64. If you compare the building **before the flood** and its **current condition**, can you give a number between 0 for “the building is completely restored and improved” and 6 for “the building still has significant damage”. You can use the intermediate values to score your answer.
   - ☐ 0 - Completely restored and improved (e.g., more water resistant or better finished)
   - ☐ 1 - Completely restored
   - ☐ 2
   - ☐ 3
   - ☐ 4
   - ☐ 5
   - ☐ - In the same state as immediately after the flood
   - ☐ I don't know

65. How many months were needed after the event to completely restore your building?

66. Did you receive any type of financial help after the flood event? If yes, which type?
   - ☐ Donations
   - ☐ Official financial help (government, authorities)
   - ☐ Insurance
   - ☐ Other

67. Other type of financial help?

68. Why did you not receive financial compensation?
*[Note: multiple answers possible!]*
   - ☐ The damage is not covered by any (insurance) policy
   - ☐ The administrative burden was excessive
   - ☐ I do not know if I am entitled to compensation
   - ☐ Did not consider compensation necessary
   - ☐ Other reasons → Q n°69
   - ☐ I don't know

69. Other reason(s) for not receiving financial compensation?

70. Did you get any donations? If yes, how much [€]?

71. Did you get any official financial help (from government or authorities)? If yes, how much [€]?

72. Did you get financial compensation by the insurance? If yes, how much [€]?

73. What is the **total amount of financial compensation** you have already received? (for example, donations, financial aid, insurance, etc.).
*[Note: Make sure the amount is in EURO! Important: We are talking about the total amount for all damages.]*

74. Which needs do you still have that have not yet been addressed?

75. What could have been done **better in terms of information/support** from government/own capabilities?

76. Did you receive a **warning** about the possibility **of flooding before or during the flood**? *[Note: Just one answer is possible]*

- ☐ No
- ☐ Yes, I received a warning before the flood occurred
- ☐ Yes, but there has never been a flood in my street
- ☐ Yes, but my street was already flooded by then

77. Which **source of information** gave you a **warning about a possible risk of flooding**? *[Note: Multi-ple answers are possible]*
- ☐ Severe weather warning (by weather service)
- ☐ Official multi-porpoise warning system (BE:BE-Alert , NL: NLalert)
- ☐ Official flood warning system (BE: Infocrue)
- ☐ Warning from local authorities (fire brigade, police)
- ☐ Warning by neighbours, friends, relatives, acquaintances
- ☐ Reporting in news
- ☐ Social media
- ☐ Personal research on internet (ex: on rain radars)
- ☐ Personal observation (ex: remarkable cloud formations, storms, thunderstorm)
- ☐ Other source → Q n°78

78. Other warning source:

| |
|---|
| |

79. How many hours did you receive the **warning before the flood** reached your house?
*[Note: Enter the time in **hours**. **(Ex: 12h)** A rough estimate is sufficient]*

| |
|---|
| |

80. Did you have time to implement precautionary measures after receiving the warning?
☐ Yes
☐ No time enough to apply precautionary measures

81. Regarding the precautionary measures that you implemented during the event, how many hours **after the warning** you **started applying emergency measures**?
*[Note: Enter the time in **hours**. **(Ex: 12h)** A rough estimate is sufficient]*.

| |
|---|
| |

82. Which of the following activities have you undertaken, or plan to undertake, to be better informed of what to do in case of a flood?
*[Note: Activities that are planned in more than 6 months are considered "unplanned"!]*

| | **In place (during the event)** | **After the event (<6 months after the event)** | **Not planned / Not possible** |
|---|---|---|---|
| Consult the existing hazard maps | | | |
| Register to national/regional warning system(s) | | | |
| Search for information on individual house flood protection | | | |
| Get an insurance | | | |

83. Which of the following **precautionary measures** did you implement **during the July 2021 floods**, after this event, or you do not currently intend to implement?
*[Note: Measurements that are planned for more than 6 months are considered "unplanned"!]*

Short term mitigation measures

| | **In place during the event** | **After the event (<6 months)** | **Not planned / not possible** |
|---|---|---|---|
| Moving the heating and/or electrical system to higher levels | | | |
| Water protections, fixed or mobile, which prevent water from entering the building/accommodation (such as partitions for windows and doors, sandbags, flood gates) | | | |
| Adaptation of the use of levels exposed to the risk of flooding | | | |
| Moving the furniture to upper floors | | | |
| Pumps | | | |
| Preventive cut-off of power, gas, and water | | | |
| Evacuating the accommodation | | | |
| Moving the house (trailer house) | | | |

Long term mitigation measures

| | **In place during the event** | **After the event (<6 months)** | **Not planned / not possible** |
|---|---|---|---|
| Water-resistant or easily renewable construction and finishing materials | | | |
| Oil tank protection (prevent flotation) | | | |
| Improvement of the stability and/or the waterproof resistance of the building | | | |
| Non-return valves at the water outlets | | | |

84. For what reason(s) did you choose **not to implement certain prevention measures** following the event?

*[Note: Multiple answers are possible]*

- ☐ Lack of financial means
- ☐ Work not covered by insurance
- ☐ Not interested
- ☐ Because such a flood should not happen again (extreme event)
- ☐ Because such a flood should not happen again (e.g., mismanagement of a dam, human error)
- ☐ Missing space
- ☐ Technically not possible
- ☐ Intention to move
- ☐ Intention to sell the building
- ☐ Overwhelmed by the event/ Don't know what to do / Lack of information

85. Before the July 2021 event, **how many times have you already been affected** by floods?

- ☐ Never before
- ☐ Once
- ☐ Twice
- ☐ Three times
- ☐ Four times
- ☐ More than four times

86. When was it (the last time)?

*[Note: Please enter the year of the last flood event you experienced in the same house*

| |
|---|
| |

87. Interview end time

| |
|---|
| |

Comments:

## Part 2 commercial

**Damage modelling (Commercial) – Field survey – PART 2: RESEARCH INFORMATION**

*Please leave the question in blank if you don't know the answer and enter 0 just when the answer is 0.*

1. Interview start time

| |
|---|
| |

2. Type of interview?
   - ☐ Field (preferred)
   - ☐ Phone

3. Water depth, time and date in the different building levels:

| | Outside the building (front door) | Outside the building (most flooded point) | Basement | Ground floor | First floor |
|---|---|---|---|---|---|
| Maximum water depth reached [m] | | | | | |
| Date and time of **water arrival** | | | | | |
| Date and time of **maximum water depth** | | | | | |
| Date and time of **water leaving the building** | | | | | |

4. Are you the owner of the business or an employee?
   - ☐ Owner
   - ☐ Employee

5. What type of business do you run?
   - ☐ Wholesaling
   - ☐ Retail
     - ☐ Kiosk
     - ☐ Supermarket
     - ☐ Discounter
     - ☐ Drug store
     - ☐ Clothing business
     - ☐ Sporting goods
     - ☐ Furniture shop
     - ☐ Cosmetics
     - ☐ Toy shop
     - ☐ Electronics
     - ☐ Art
     - ☐ Department store
     - ☐ Medical Retail (opticians, hearing aid, prosthesis)
     - ☐ Book shop
     - ☐ Food (Bakery, blutcher etc.)
     - ☐ Pet supplies
     - ☐ Motor vehicle shop
     - ☐ Bicycle shop
     - ☐ Household appliance store
     - ☐ Other: _______________
   - ☐ Manifacturing
   - ☐ Energy and water supply
   - ☐ Water and waste disposal services
   - ☐ Farm/farming operation
   - ☐ Service industry
     - ☐ Food
     - ☐ Accomodations
     - ☐ Medical services (hospital, doctor, therapist etc.)
     - ☐ Veterinary medicine
     - ☐ Beauty & Wellness (haridresser, tattoo studio, cosmetics, massage etc.)
     - ☐ Care industry (childcare, nursin home etc.)
     - ☐ Education (school etc.)
     - ☐ Leisure industry (Cinema, Gym etc.)
     - ☐ Technical/Electronic service provider/repair
     - ☐ Financial services
     - ☐ Insurance services
     - ☐ Undertaker
     - ☐ Shipping service
     - ☐ Mechanical service (car/bicycle servie)
     - ☐ Clothes services (Tailoring, shoemaker etc.)
     - ☐ Engineering Services
     - ☐ Law office
   - ☐ Other

6. Other type of business?

| |
|---|
| |

7. To what do you attribute **the flooding of your business**?
*[Note: multiple answers possible!]*

☐ Runoff (for example, rainwater flowing down uncontrolled on the road or on neighbouring land)
☐ Overflow of a watercourse (for example, a stream or a river having overflowed its bed)
☐ Saturation of the sewage system, which could no longer take water from the roads.
☐ Water has directly entered the rooms below street level (e.g., backflow through drains, toilets, showers, or sewage system)
☐ Lack of drainage on the property (overflowing depressions in the garden, overflowing manholes, failing drainage of the gutters)
☐ Failure of a dike or dam / failure of a flood retention basin
☐ Groundwater flood (rise of groundwater)
☐ I don't know
☐ Other cause of flooding → Q n°6

8. Other cause of flooding:

| |
|---|
| |

9. How was the business area affected by the flood used before the flood event?
☐ Workshop
☐ Sales area
☐ Office area
☐ Gastronomy area
☐ Hotel/Guest room
☐ Surgery room
☐ Gastronomy outdoor area
☐ Other outdoor area
☐ Agricultural area
☐ Manufacturing hall
☐ Classroom
☐ Other

10. Other use of flooded business area?

| |
|---|
| |

11. Were the premises unusable after the flood?

☐ No
☐ Temporarily
☐ Certain duration
☐ Still unusable
☐ Won't be usable again

12. For how long were the premises unusable?

*[Please enter the duration in days]*

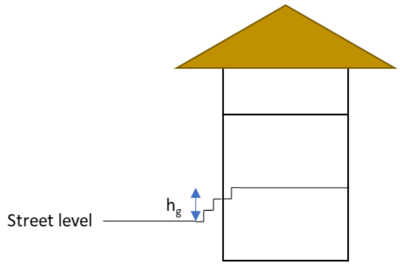
13. What do you think: Could an **average person have been able to stand effortless in the flooded street** in the immediate vicinity of your house, would (s)he has had to **make efforts to stay upright** or would (s)he have been **swept away**?

*[Note: At the most dangerous moment, i.e., the moment of the highest flow velocity]*

☐ Could have easily stood
☐ Should have made efforts to stay upright
☐ Would have been swept away by the current
☐ The water was too deep to stand
☐ I don't know

14. How high do you have to climb to reach the ground floor from the street level (sidewalk)? [*to be measured (ex: 0.30 m)*]

*[Note: This corresponds to steps, located both outside and in-side, which you must climb from street level to reach the ground floor; it's not about the steps you have to climb from the basement to reach the ground floor. Indicate the value in **meters**].*



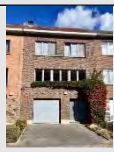
15. At **what level(s)**, including the basement, was the **building damaged**?
*[Note: Please mark ALL relevant levels!]*

☐ Basement
☐ Ground floor
☐ 1st floor
☐ 2nd floor
☐ 3rd floor
☐ 4th floor
☐ Attic
☐ No damage in any level
☐ I don't know

16. On which levels of the building was your business located before the flood?
*(Multiple answers possible)*

☐ Basement
☐ Ground floor
☐ First floor
☐ Second floor
☐ Third floor or higher

17. Are the following levels finished in the building?
*[Note: Before the floods. Finished means with plaster, painting or any additional covering material in the walls and floor]*

| | **Yes** (even if partially finished) | **No** (e.g., garage, storage area …) |
|---|---|---|
| Basement | | |
| Ground floor | |  (sample photograph) |

*18.* Which of the following materials were transported or deposited by water in the business/building, or in direct contact with it?
*[Note: Please read and mark as appropriate!]*

☐ Mud
☐ Sand/stone
☐ Vegetation (wooden logs, branches, roots)
☐ Garbage
☐ Rubble (material from demolished buildings or structures upstream)
☐ Large objects (e.g., tanks, cars, containers, interlocked objects)
☐ None
☐ I don't know

19. From the previous materials transported by water, could you estimate their **maximum size**?
    *[Note: Please enter the estimated length [m]]*

20. How strong was the water flow in the immediate vicinity of the business/building? Please give me a number between 1 for “calm flow”; and 6 for “torrential”. You can use the intermediate values to score your answer.
    *[Note: only one answer possible!]*

- ☐ 1 - Calm flow
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6 - Torrential flow

21. Has your business/building been contaminated by any of the following substances?
    *[Note: read and mark as appropriate. Several possible responses!]*

- ☐ Chemicals, paints, varnishes, pesticides, small amounts of motor oil
- ☐ Sewage or faeces
- ☐ Hydrocarbons (fuel, fuel oil, etc.)
- ☐ No, no pollution due to these substances
- ☐ I don't know

22. What is the **surface** of your **ground floor**?
    *[Note: Enter the area in square meters. If necessary, ask for a rough estimate.]*

23. Which of the **following items** did you need to **replace**?
    *[Note: Please write down the number of items in each category. Please read aloud, multiple answers are possible.]*

- ☐ Machinery
- ☐ Furniture
- ☐ Tools
- ☐ Electrical equipment
- ☐ Boiler
- ☐ Sales goods
- ☐ Archive
- ☐ Other voluminous and/or expensive items
- ☐ No, no valuable object
- ☐ I don’t know

24. Which other voluminous and expensive items?

25. Have you had a business vehicle impacted by the flood? If yes, how many?
☐ Car : ___________
☐ Motorcycle : ___________
☐ Truck: ___________

26. How much do you estimate the total cost of replacing your damaged sales goods?
*[Note: Make sure the amount is in EURO!!]*

27. What is this **value based on**?
   ☐ Invoices for work carried out
   ☐ Trades quotes
   ☐ Expert estimate, for example from the insurance company
   ☐ Personal estimation

28. Is this estimation including the replacement of all damaged sales goods or are you still missing some that are not included in the cost you previously mentioned?
   ☐ Yes, all the damaged sales goods are included.
   ☐ No, there are damaged sales goods that have not been replaced.

29. Is the compensation procedure with the insurance company over, so the amount for damaged sales goods compensation of is already defined, or is the process with the insurance company still ongoing and the amount of damaged sales goods to be refunded can change?
   ☐ Yes, the compensation is over. The damage cost for damaged sales goods is fixed.
   ☐ No, there compensation is still ongoing. The damage cost for damaged sales goods could change.

30. How much do you estimate the total cost of replacing all your damaged business items (equipment)?
*[Note: Make sure the amount is in EURO]*

31. What is this **value based on**?
   ☐ Invoices for work carried out
   ☐ Trades quotes
   ☐ Expert estimate, for example from the insurance company
   ☐ Personal estimation

32. Is this estimation including the replacement of all the damaged items or are you still missing some that are not included in the cost you previously mentioned?
   ☐ Yes, all the damaged items are included.
   ☐ No, there are damaged items that have not been replaced.

33. Is the compensation procedure with the insurance company over, so the amount for damaged items' compensation of is already defined, or is the process with the insurance company still ongoing and the amount of damaged items to be refunded can change?
   ☐ Yes, the compensation is over. The damage cost for damaged business items is fixed.
   ☐ No, there compensation is still ongoing. The damage cost damaged business items could change.

34. Have you completely replaced the damaged business items or do they still show obvious defects and gaps as a result of the flood?

    *Please give me a number between 1 for “I have completely replaced all affected household items since then” and 6 for “Household items still have significant gaps and defects”. You can use the intermediate values to score your answer.*

    - ☐ 1 - Fully functional
    - ☐ 2
    - ☐ 3
    - ☐ 4
    - ☐ 5
    - ☐ 6 - Household items still have significant defects or shortcomings
    - ☐ I don't know

35. How many months after the event did it take you to fully recover (repair or replace) your business items?

| |
|---|
| |

36. Which **description** matches best the building?
    - ☐ House
        - ☐ Detached house (four facades)
        - ☐ Semi-detached house (three facades)
        - ☐ Attached house (two facades)
        - ☐ Appartement block
    - ☐ Hall
    - ☐ Other → Q n°27

37. Other description of your business/building:

| |
|---|
| |

38. How many **levels** does the building have **in total**, including basement, ground floor, and attic?

    *[Note: Include the attic, even if it is not finished!]*

| |
|---|
| |

39. What is the **construction method** of the different building levels?
*[Note: Multiple answers possible (for mixed construction methods). We must answer to this question only when we have a piece of evidence, or we fully trust the knowledge of the person. Otherwise, we must tick “I don’t know”]*

| | **Basement** | **Ground floor** | **Upper floors** |
|---|---|---|---|
| Reinforced concrete | | | |
| Timber frame | | | |
| Concrete masonry | | | |
| Clay masonry | | | |
| Prefabricated | | | |
| Natural stone | | | |
| Cavity walls | | | |
| Half-timbered building (FR: Colombage, DE: Fachwerkhaus, NL: Vakwerkhuis) | | | |
| I don’t know | | | |
| Other method → Q n°0 | | | |

40. Other construction method(s):

| | **Basement** | **Ground floor** | **Upper floors** |
|---|---|---|---|
| Other method | | | |

41. Can you tell me approximately when the building was built?
   - ☐ Before 1875
   - ☐ 1875-1918
   - ☐ 1919-1945
   - ☐ 1946-1970
   - ☐ 1971-1990
   - ☐ 1991-2000
   - ☐ 2001-2010
   - ☐ After 2011

42. Has the building undergone a major renovation? If so, when was the last time?
*[Note: Write down the year, only "major renovations" as the replacement of the soil, walls or isolation are meant.]*

43. What is the **heating system** of the business?
    *[Note: multiple answers are possible.]*
    - ☐ Coal heating
    - ☐ Gas heating
    - ☐ Oil heating
    - ☐ Electric heating or night storage
    - ☐ District heating
    - ☐ Pellet or wood chip heating, wood heating
    - ☐ Air-source heat pump
    - ☐ Ground source heat pump
    - ☐ Other heating system(s) → Q n°36

44. Other heating system(s):

| |
|---|
| |

45. At what level was the heating system at the time of the disaster?
    - ☐ Basement
    - ☐ Ground floor
    - ☐ 1st floor
    - ☐ 2nd floor
    - ☐ 3rd floor
    - ☐ 4th floor
    - ☐ 5th floor
    - ☐ Attic
    - ☐ Each level, each apartment
    - ☐ Dependency outside the building (annex)
    - ☐ Other place where the heating system was
    - ☐ I don't know

46. Other place where the heating system was?

| |
|---|
| |

47. Please describe the building damage in more detail using the following list.
*[Note: Please read the text! Many possible responses!]*
- ☐ Moisture infiltration only
- ☐ Wooden structure: expansion / contraction
- ☐ Slight cracks, damage to the exterior coating of the building (masonry, plaster) [structural and non-structural damage]
- ☐ Damage to interior linings
- ☐ Damage to the pavement (Floor covering material)
- ☐ Damage to doors
- ☐ Damage to windows
- ☐ Significant cracks or settlements, or deformations of walls and ceilings
- ☐ Collapse of construction elements (walls, ceilings)
- ☐ Building collapse
- ☐ Demolition required
- ☐ I don't know

48. If you add up the costs (material and labor) of all necessary reparation work on and in the building, what was the total amount of damage to the building?
*[Note: give the estimate that seems most likely to you in EURO. If asked: this also includes rental costs for equipment such as dehumidifiers, space heaters, etc. Important: The total amount of ALL damage is meant!]*

49. What is this **value based on**?
- ☐ Invoices for work carried out
- ☐ Trades quotes
- ☐ Expert estimate, for example from the insurance company
- ☐ Personal estimation
- ☐ Other source(s) → Q°52

50. Other source(s):

51. Is this estimation including the reparation of all damages in the building or are you still missing some works to do that are not included in the cost you previously mentioned?
- ☐ Yes, all the damages are included.
- ☐ No, there are damages that are still missing.

52. Is the compensation procedure with the insurance company over, so the amount of damage for the compensation is already defined, or is the process with the insurance company still ongoing and the amount of damage to be refunded can change?
- ☐ Yes, the compensation is over. The damage cost is fixed.
- ☐ No, the compensation is still ongoing. The damage cost could change.

53. To what do you primarily attribute the damage to the building?
*[Note: please read the text! Several possible responses!]*
- ☐ Water level
- ☐ Flow velocity
- ☐ Mud and sediment deposits
- ☐ Impacts of floating objects (tree trunks, debris, washed away vehicles, etc.)
- ☐ Water pressure
- ☐ Flood duration
- ☐ I don't know

54. Regarding the cleaning of your business, how many hours of cleaning did you report to insurance?
*[Note: Unit = Hour]*

55. What compensation did you receive from the insurance company for the cleaning hours?
*[Note : in euro]*

56. How much did it cost you to buy or rent equipment related to the dehumidification of your building after the floods (dehumidifier, heat gun...)?
*[Note: in euro]*

57. If your business/building was contaminated by hydrocarbons, how much did it cost you to decontaminate it?
*[Note: in euro]*

58. Can you indicate the total amount of the costs related to the cleaning of the building (waste disposal, dehumidification, decontamination)?
*[Note: in euros.]*

59. What is included in the total cost of the cleaning of the building?
   - ☐ Waste disposal
   - ☐ Dehumidification
   - ☐ Decontamination

60. What is the total amount of damage approved by the insurance company?
*[Note: Make sure the amount is stated in EURO! On request: only the insurance for damage to or in the house is concerned; the car insurance should not be taken into account! If zero euros were declared, write down zero].*

61. What is included in the total amount approved by the insurance?
- ☐ Reparation of the building
- ☐ Replacement of business equipment
- ☐ Replacement of sales goods
- ☐ Compensation for reduced turnover

62. Did your business had to close because of the flood?
- ☐ No
- ☐ Temporarily
- ☐ Still closed
- ☐ Won't open again

63. For how long was your business closed after the flood event?
*[Note: Please enter the duration in days]*

64. Regarding the time that the business has been closed due to the flood event, which are the reasons why it has been or was closed?
- ☐ Waiting for reimbursements
- ☐ Reconstruction time
- ☐ Other reason

65. Other reason for closing the business after the flood event.

66. How many people worked in FTE at the business before the flood?
*[Note: FTE means full time equivalent]*

67. How much do you estimate the total loss regarding the turnover of your business due to the flood?
*[Note: Please give the answer in EURO]*

68. Can you estimate how big your turnover is relatively to the time before the flood?
    *[Note: Please give the answer in %.]*

69. On what is this number based on?
- ☐ Estimations
- ☐ Accounting

70. If you compare the building **before the flood** and its **current condition**, can you give a number between 0 for "the building is completely restored and improved" and 6 for "In the same state as immediately after the flood". You can use the intermediate values to score your answer.
    - ☐ 0 - Completely restored and improved (e.g., more water resistant or better finished)
    - ☐ 1 - Completely restored
    - ☐ 2
    - ☐ 3
    - ☐ 4
    - ☐ 5
    - ☐ 6 - In the same state as immediately after the flood
    - ☐ I don't know

71. How many months were needed after the event to completely restore your business/building?

72. How many people lost their income temporarily?

73. How long was their work activity interrupted?
    *[Note: Please note the period in days]*

74. How long of this period have you been able to pay your staff?
    *[Note: Please note the period in days]*

75. How many people lost their job and henceforth their income completely?

76. If the business is still open or reopened, how many people are working there (in FTE)? *[Note: FTE means full time equivalent]*

77. What is the total amount of financial compensation you have already received? (for example, donations, financial aid, insurance, etc.).
*[Note: Make sure the amount is in EURO! Important: We are talking about the total amount for all damages.]*

78. Why did you not receive financial compensation?
*[Note: multiple answers possible!]*
- ☐ The damage is not covered by any (insurance) policy
- ☐ The administrative burden was excessive
- ☐ I do not know if I am entitled to compensation
- ☐ Did not consider compensation necessary
- ☐ Other reasons → Q n°69
- ☐ I don't know

79. Other reason(s) for not receiving financial compensation?

80. Which needs do you still have that have not yet been addressed?

81. What could have been done **better in terms of information/support** from government/own capabilities?

82. Did you receive a warning about the possibility of flooding before or during the flood?
*[Note: Just one answer is possible]*
- ☐ No
- ☐ Yes, I received a warning before the flood occurred
- ☐ Yes, but there has never been a flood in my street
- ☐ Yes, but my street was already flooded by then

83. Which **source of information** gave you a **warning about a possible risk of flooding**?
*[Note: Multiple answers are possible]*
- ☐ Severe weather warning (by weather service)
- ☐ Official multi-porpoise warning system (BE:BE-Alert , NL: NLalert, D: NINA, WarnWetter (DWD), KatWarn)
- ☐ Official flood warning system (BE: Infocrue)
- ☐ Warning from local authorities (fire brigade, police)
- ☐ Warning by neighbours, friends, relatives, acquaintances
- ☐ Reporting in news
- ☐ Social media
- ☐ Personal research on internet (ex: on rain radars)
- ☐ Personal observation (ex: remarkable cloud formations, storms, thunderstorm)
- ☐ Other source → Q n°78

84. Other warning source:

| |
|---|
| |

85. How many hours did you receive the **warning before the flood** reached your business/building?
*[Note: Enter the time in hours. (Ex: 12h) A rough estimate is sufficient]*

| |
|---|
| |

86. Did you have time to implement precautionary measures after receiving the warning?
☐ Yes
☐ No time enough to apply precautionary measures

87. Regarding the precautionary measures that you implemented during the event, how many hours **after the warning** you **started applying emergency measures**?
*[Note: Enter the time in hours. (Ex: 12h) A rough estimate is sufficient].*

| |
|---|
| |

88. Which of the following activities have you undertaken, or plan to undertake, to be better informed of what to do in case of a flood?

*[Note: Activities that are planned in more than 6 months are considered "unplanned"!]*

| | **In place (during the event)** | **After the event (<6 months after the event)** | **Not planned / Not possible** |
|---|---|---|---|
| Consult the existing hazard maps | | | |
| Register to national/regional warning system(s) | | | |
| Search for information on individual building flood protection | | | |
| Get an insurance | | | |

89. Which of the following **precautionary measures** did you implement **during the July 2021 floods**, after this event, or you do not currently intend to implement?

*[Note: Measurements that are planned for more than 6 months are considered "unplanned"!]*

Short term mitigation measures

| | **In place during the event** | **After the event (<6 months)** | **Not planned / not possible** |
|---|---|---|---|
| Moving the heating and/or electrical system to higher levels | | | |
| Water protections, fixed or mobile, which prevent water from entering the building (such as partitions for windows and doors, sandbags, flood gates) | | | |
| Adaptation of the use of levels exposed to the risk of flooding | | | |
| Moving the furniture to upper floors | | | |
| Pumps | | | |
| Preventive cut-off of power, gas, and water | | | |
| Evacuating the building | | | |
| Moving the house (trailer house) | | | |

Long term mitigation measures

| | **In place during the event** | **After the event (<6 months)** | **Not planned / not possible** |
|---|---|---|---|
| Water-resistant or easily renewable construction and finishing materials | | | |
| Oil tank protection (prevent flotation) | | | |
| Improvement of the stability and/or the waterproof resistance of the building | | | |
| Non-return valves at the water outlets | | | |

90. For what reason(s) did you choose **not to implement certain prevention measures** following the event?

*[Note: Multiple answers are possible]*

- ☐ Lack of financial means
- ☐ Work not covered by insurance
- ☐ Not interested
- ☐ Because such a flood should not happen again (extreme event)
- ☐ Because such a flood should not happen again (e.g., mismanagement of a dam, human error)
- ☐ Missing space
- ☐ Technically not possible
- ☐ Intention to move
- ☐ Intention to sell the building
- ☐ Overwhelmed by the event/ Don't know what to do / Lack of information

91. Before the July 2021 event, how many times have you already been affected by floods?

- ☐ Never before
- ☐ Once
- ☐ Twice
- ☐ Three times
- ☐ Four times
- ☐ More than four times

92. When was it (the last time)?

*[Note: Please enter the year of the last flood event you experienced in the same house*

| |
|---|
| |

93. Are you the owner or tenant of the building or structure where the business is located?

*[Note: Co-owners are considered owners (example: co-ownership of a married couple, home-owners, associations, etc.]*

- ☐ I am a tenant
- ☐ I own the housing unit (e.g., a flat in an apartment block)
- ☐ I own the whole building

94. Interview end time

**Comments:**

# B – Python Code

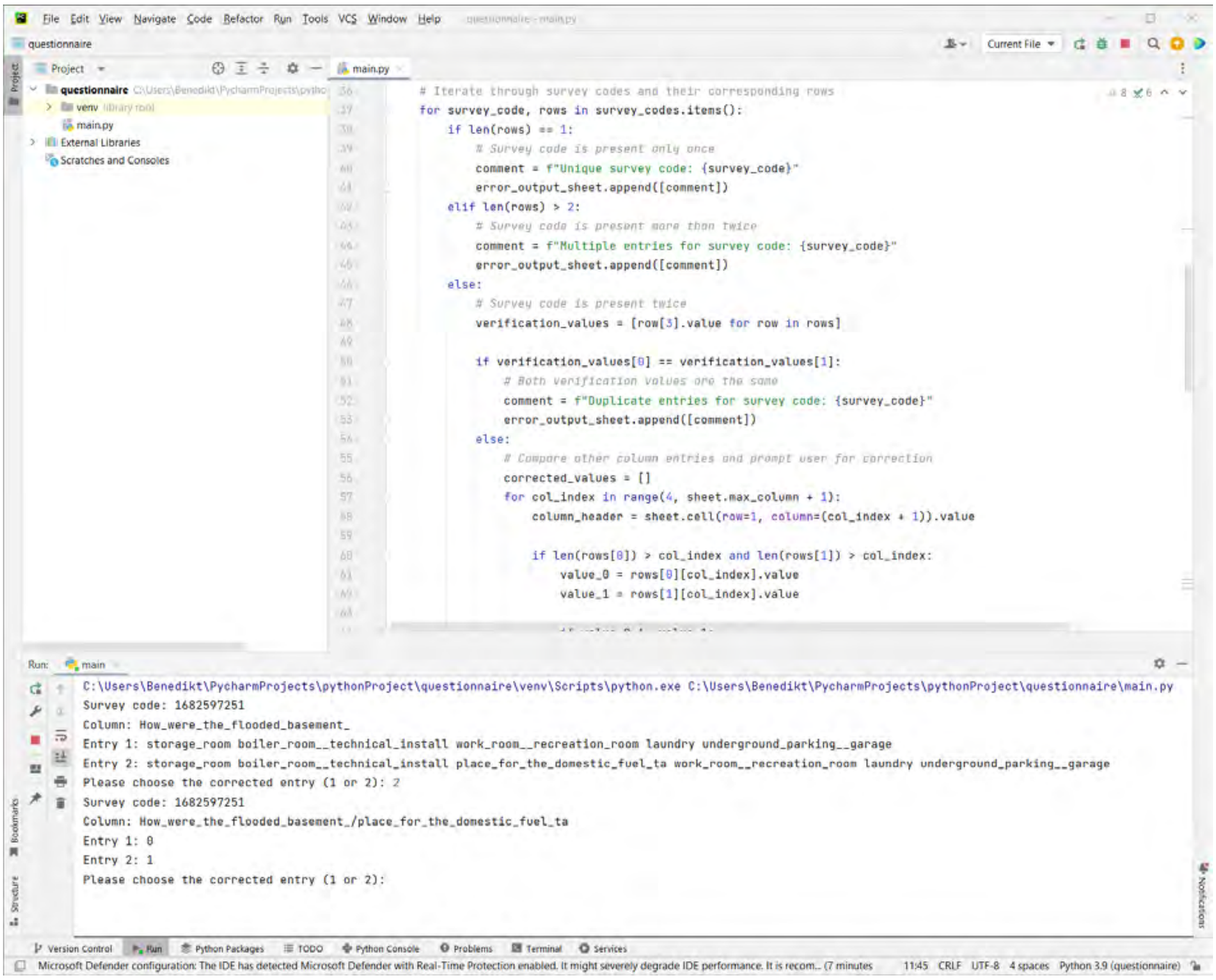



*Figure 140. Developed python code for survey comparison and correction.*

# C – Additional figures

## Belgium

### Survey statistics

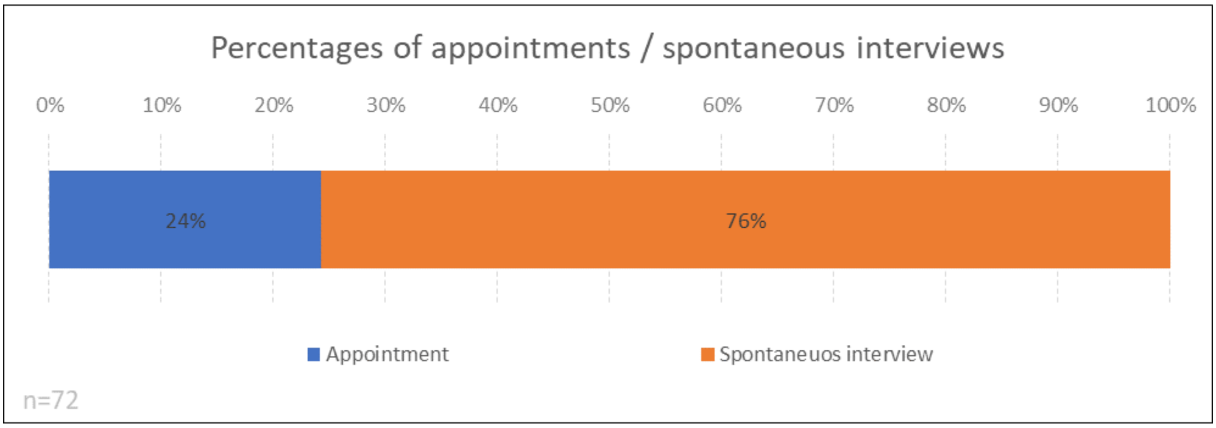



*Figure 141 : Percentages of appointments/spontaneous interviews, Belgium.*

### Part 1

*Table 5 : List of other recorded socio-professional categories than available in question 12 and their abundance, Belgium (questionnaire part 1, question 13).*

| Abundance | Other socio-professional categories |
|---|---|
| 1 | Intermediate profession |

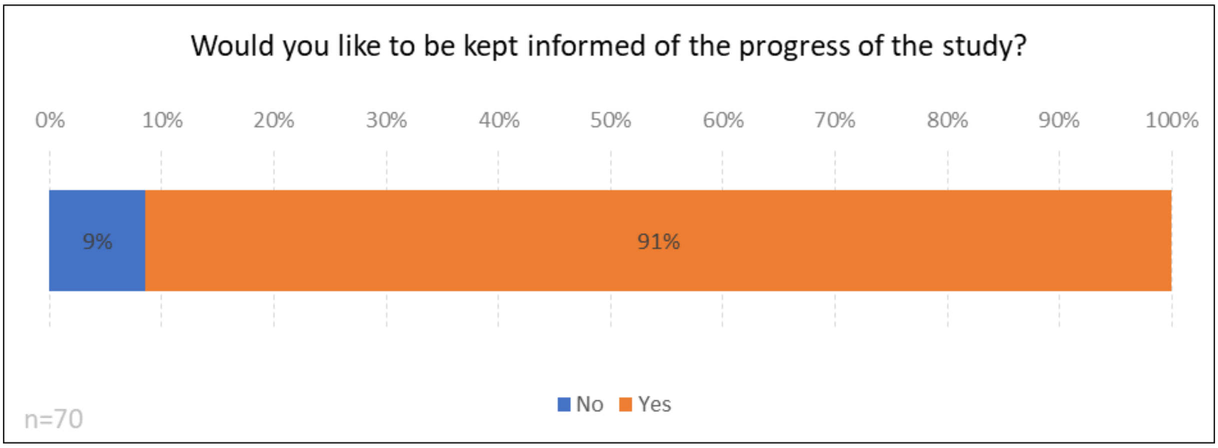



*Figure 142: Percentages of participants who want to be kept informed of the progress of the study, Belgium (questionnaire part 1, question 14).*

## Part 2

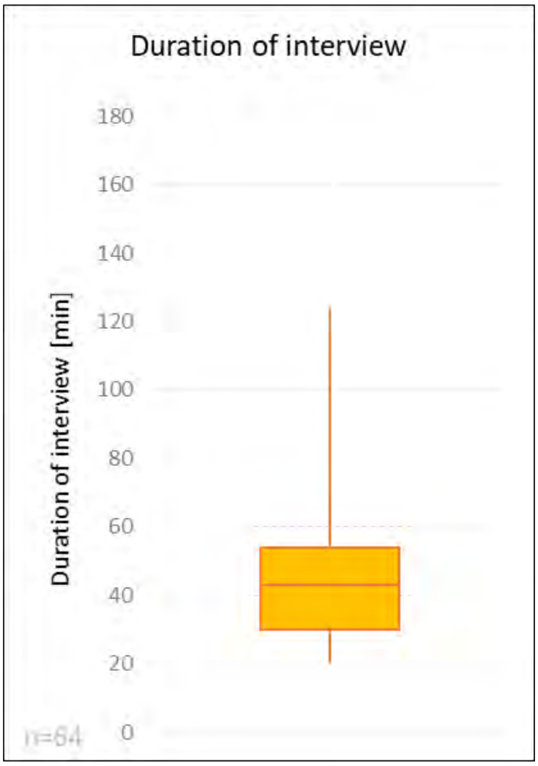



*Figure 143: Boxplot of the interview durations, Belgium (questionnaire part 2 residential, questions 1 & 87).*

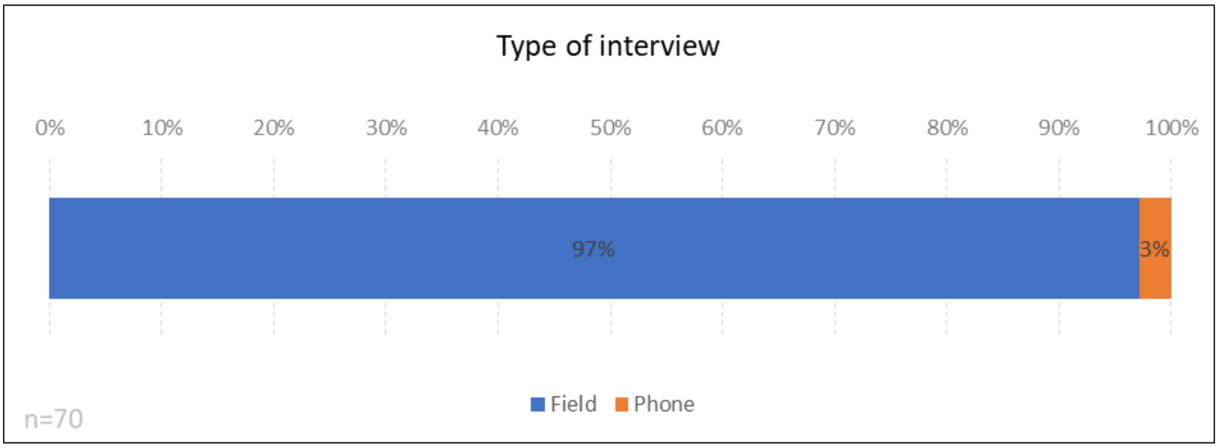



*Figure 144 : Type of interview, Belgium (questionnaire part 2 residential, question 2).*

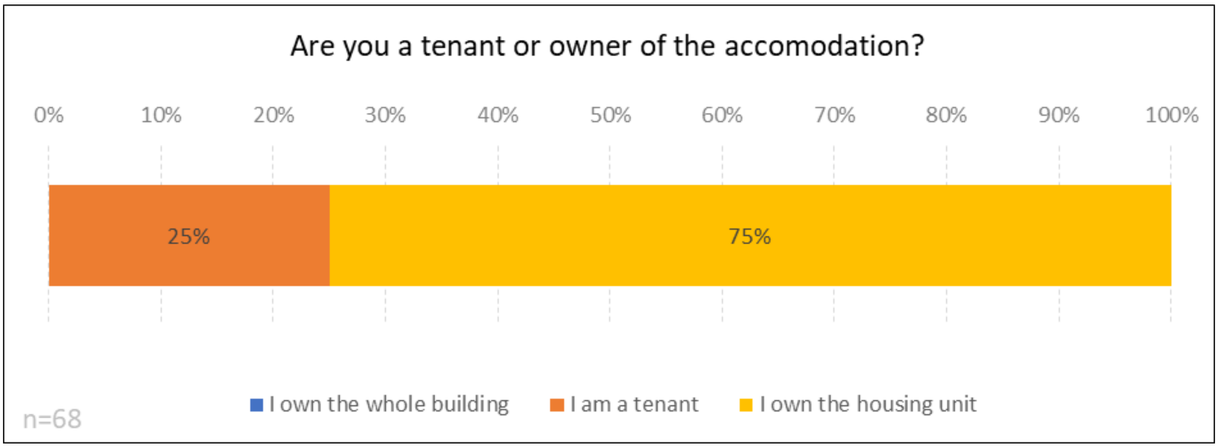



*Figure 145: Percentages of the participants who are owners or tenants of their home, Belgium (questionnaire part 2 residential, question 4).*

*Table 6: List of other recorded causes of flooding, Belgium (questionnaire part 2 residential, question 6).*

| Abundance | Other causes of flooding |
|---|---|
| 36 | Eupen Dam |
| 4 | Mismanagement of the Dam |
| 1 | Walloon Region |
| 7 | Human error |
| 1 | Climate change has nothing to do with the person |
| 1 | Competition of circumstances |
| 1 | Bad regional planning |
| 2 | Negligence |
| 1 | Soil infiltration |
| 12 | Exceptional precipitation |
| 2 | Period of drought before the flood which assembled the soil |
| 2 | slow down the infiltration in the Fagnes |
| 3 | Artificial floor |
| 1 | Continuous rain |
| 3 | Waterproofing of soil |
| 3 | Global warming |
| 2 | Urbanisation |
| 3 | Poor maintenance of rivers (the last date of 1963 according to the person), absence of cleaning |
| 1 | Significant precipitation |
| 1 | Transformation of the river into a canal by the destruction of the natural vegetation of the river |
| | Lack of maintenance |
| n=60 | |

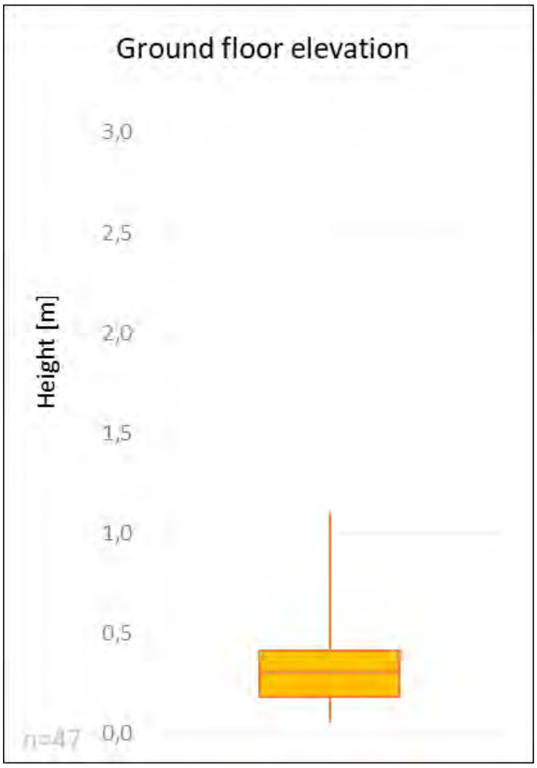
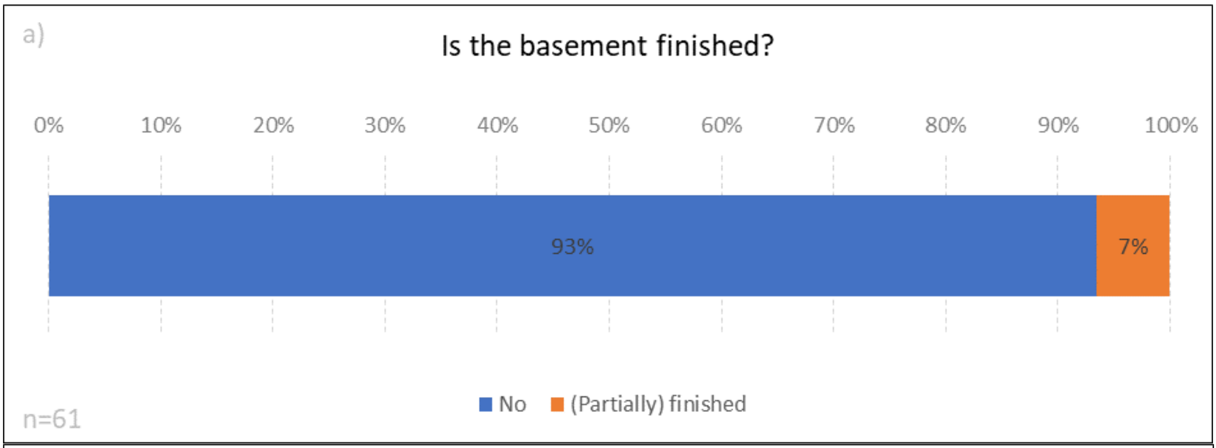



*Figure 146: Box plot of the elevation between street level and the ground floor of the buildings, Belgium (questionnaire part 2 residential, question 8).*



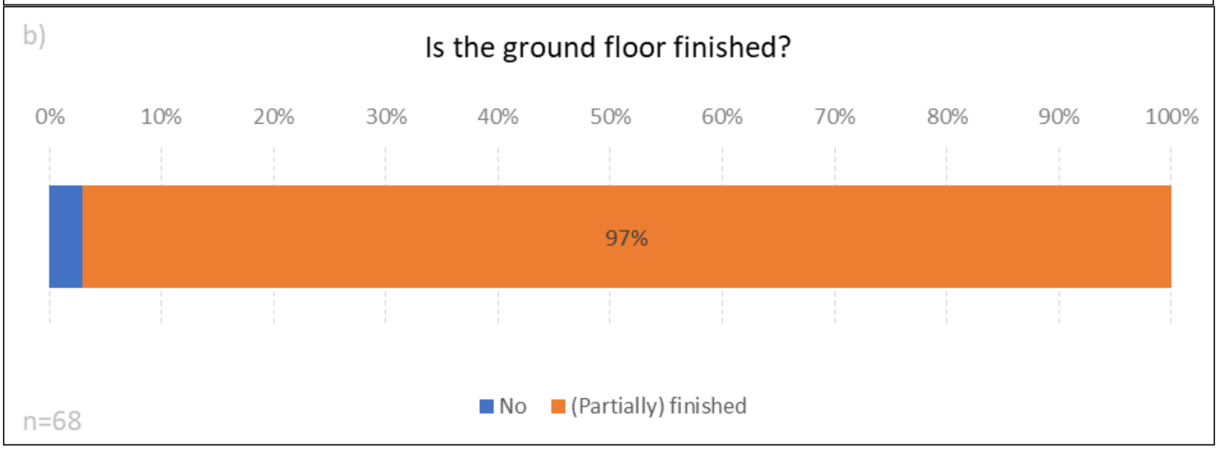




*Figure 147 : Percentage of finished levels in the buildings of the participants, a) basement and b) ground floor, Belgium (questionnaire part 2 residential, question 10)*

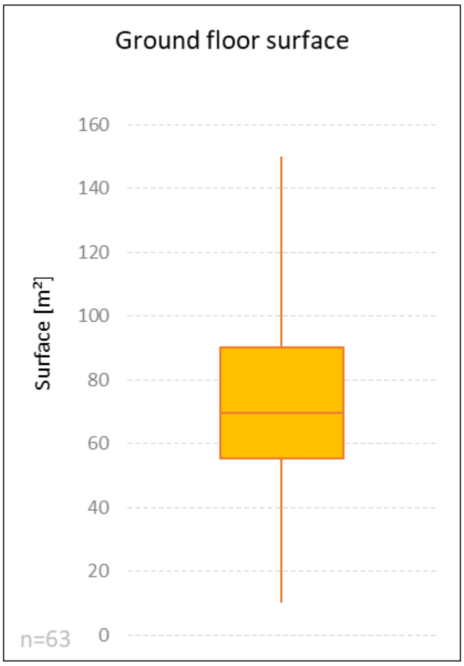



*Figure 148: Box plot of the sizes of the ground floor areas of the participants homes, Belgium (questionnaire part 2 residential, question 15).*

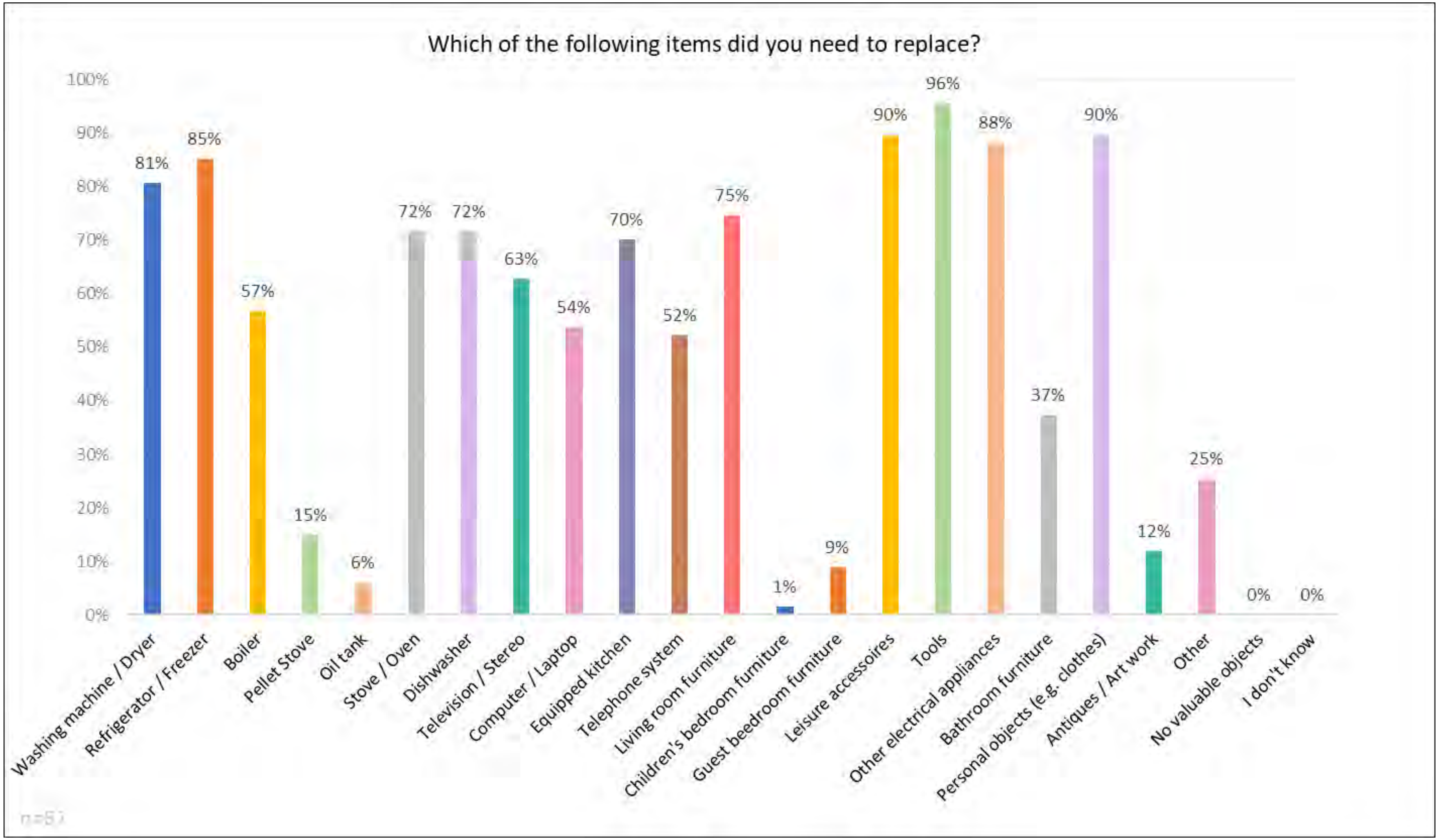
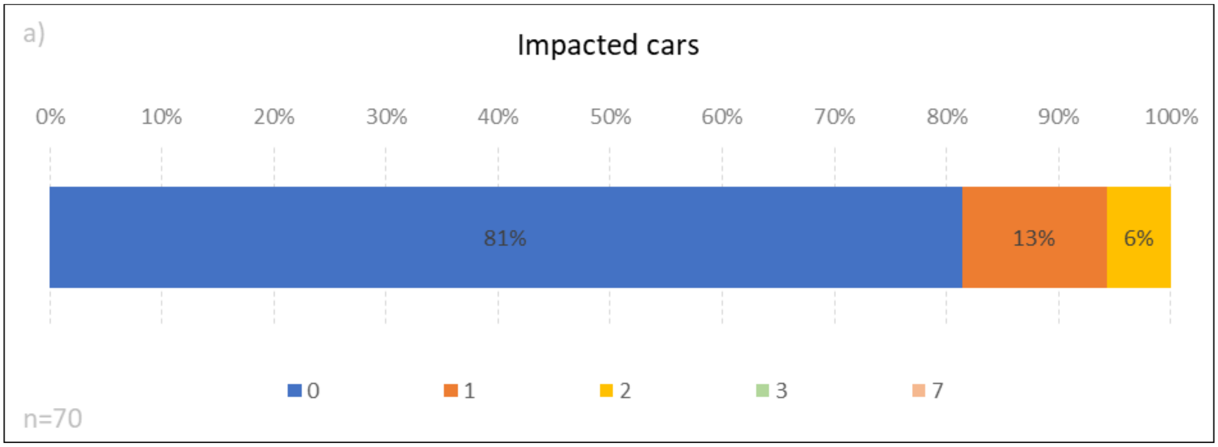



*Figure 149: Percentages of the household items, the participants had to replace, Belgium (questionnaire part 2 residential, question 16).*

*Table 7:Other voluminous/expensive items than available in question 16, Belgium (n=10) (questionnaire part 2 residential, question 17).*

| Abundance | Other voluminous/expensive items |
|---|---|
| 1 | Work equipment |
| 1 | Trailer |
| 1 | Heat pump |
| 1 | Water softener |
| 1 | Mobile home |
| 1 | WC |
| 1 | Convector |
| 1 | Piano |
| 1 | Gas home |
| 1 | Bisons skins |
| 1 | Car repair equipment |
| 1 | Compressor |
| 1 | Wood foyer |



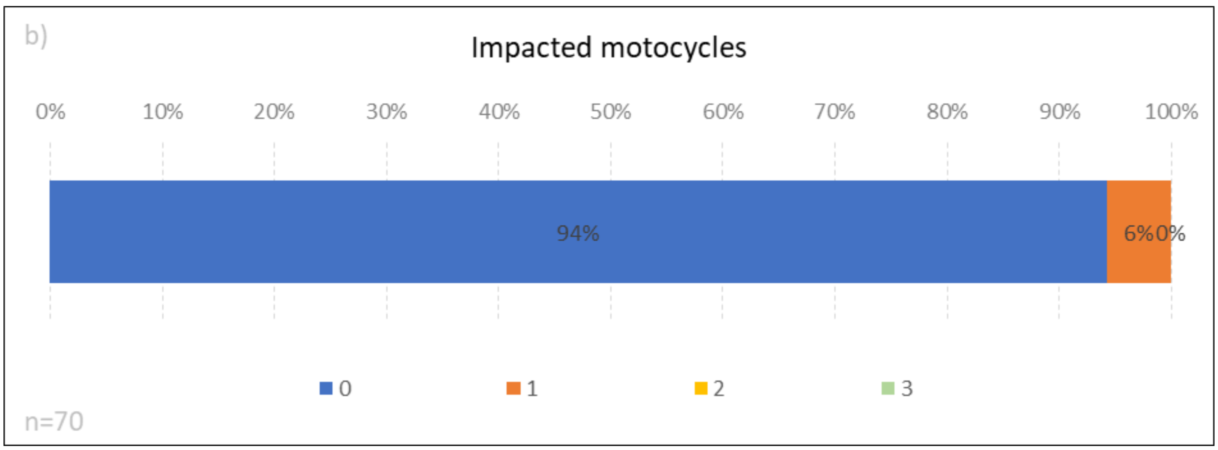




*Figure 150: Percentages of participants who had a) one/several car(s) or b) one/several motorcycles impacted by the flood, Belgium (questionnaire part 2 residential, question 18).*

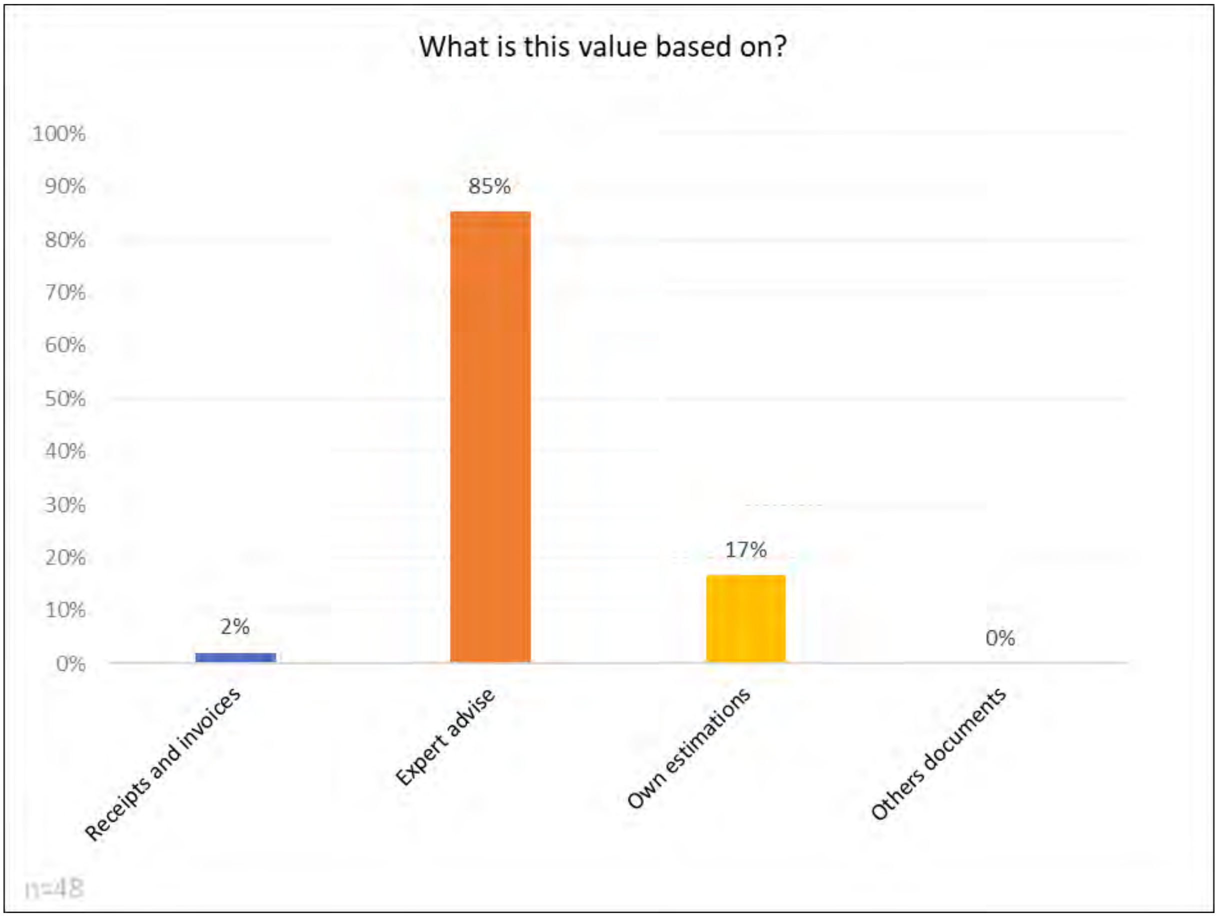



*Figure 151: Percentages of the base of the values from question 19, Belgium (questionnaire part 2 residential, question 20).*

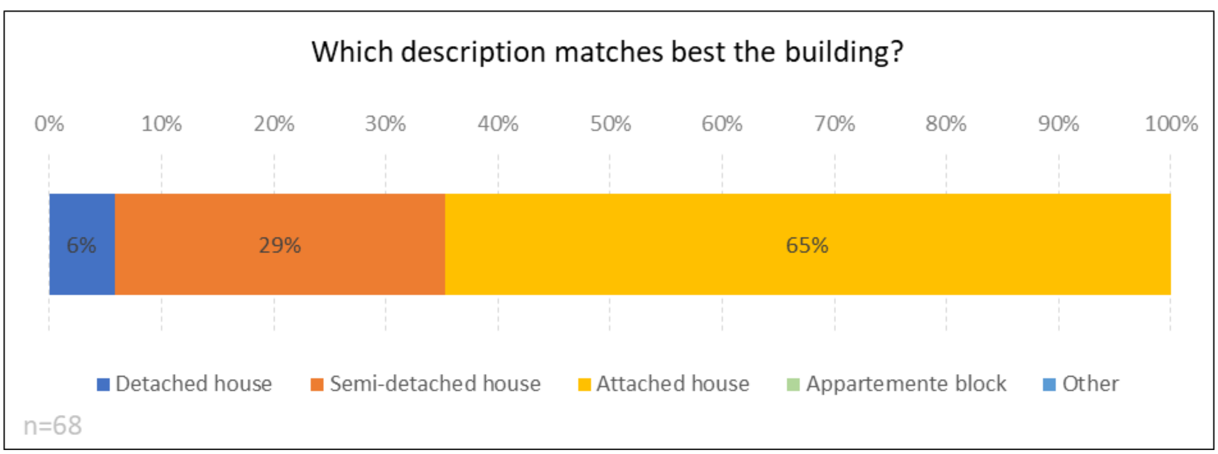



*Figure 152: Percentage of which types of buildings the participants live in, Belgium (questionnaire part 2 residential, question 26).*

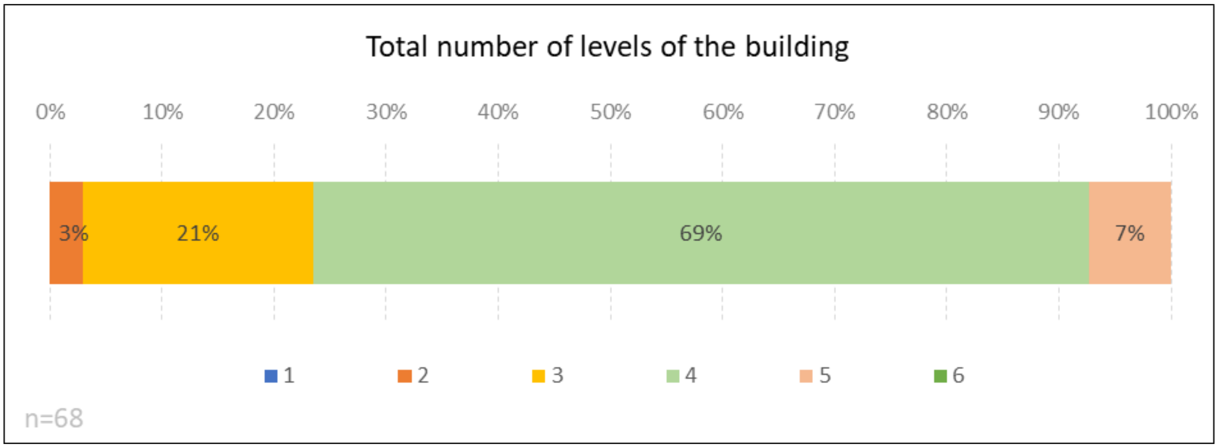
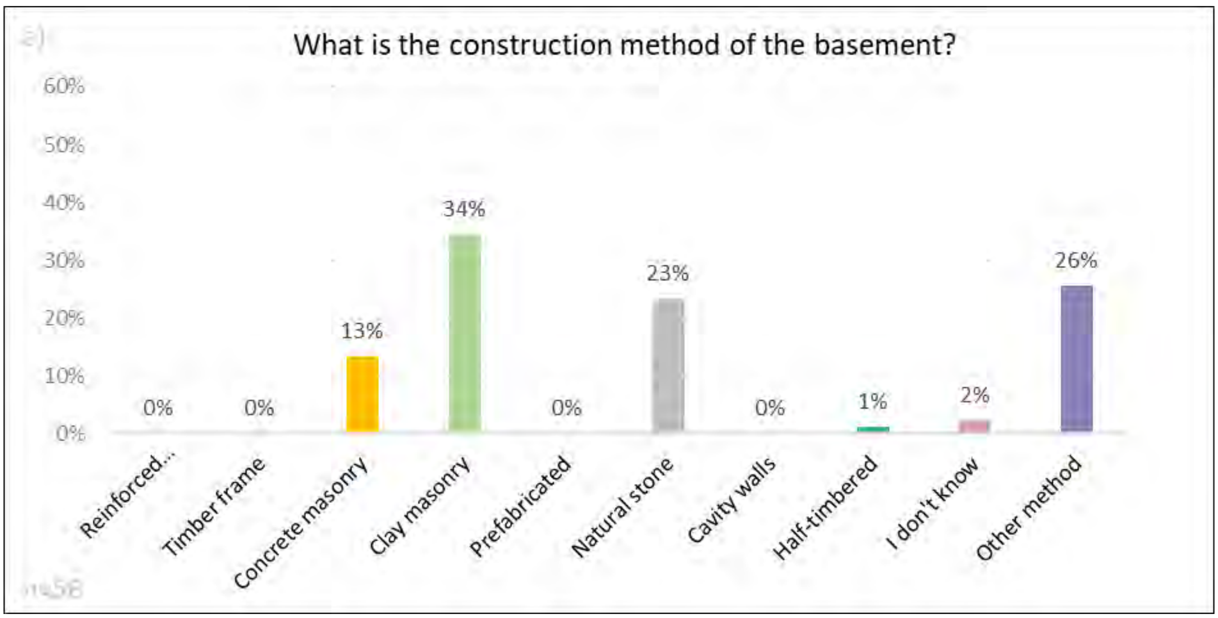



*Figure 153: Total number of levels of the buildings the participants live in, Belgium (questionnaire part 2 residential, question 28).*



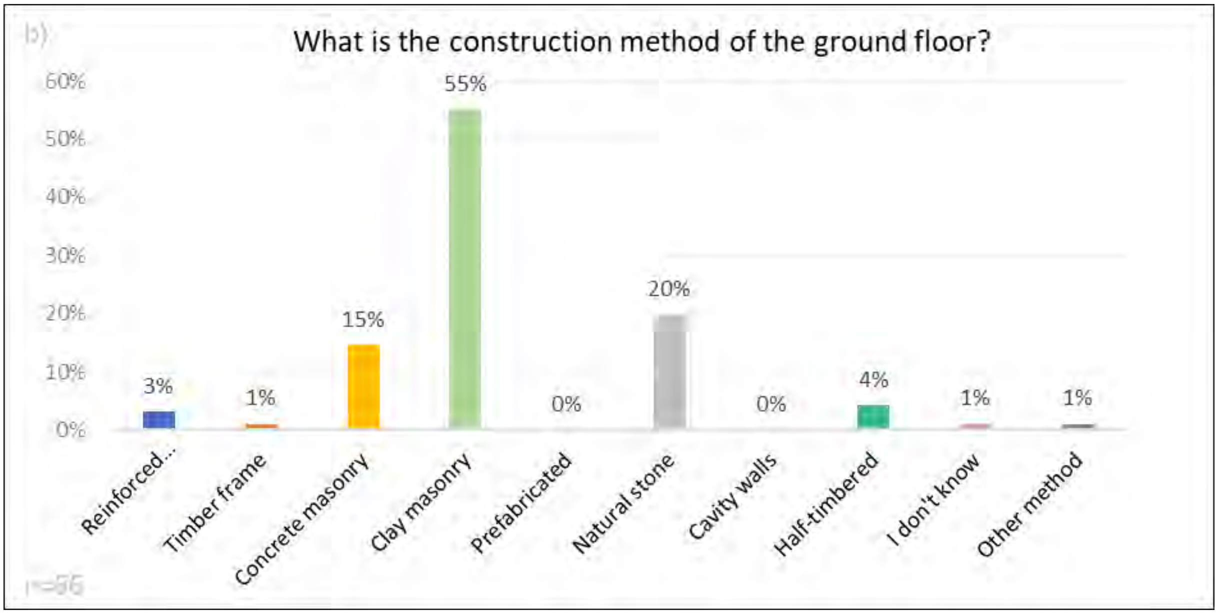



*Figure 154: Percentages of the construction methods of the a) basement, b) ground floor of the buildings the participants live in, Belgium (questionnaire part 2 residential, question 29).*

*Table 8 : Other building methods of the basement than mentioned in question 29, Belgium (questionnaire part 2 residential, question 30).*

| Abundance | Other building methods basement |
|---|---|
| 20 | Boulders |
| 1 | Mixture of stones |
| 1 | Half-timbered |
| n=22 | |

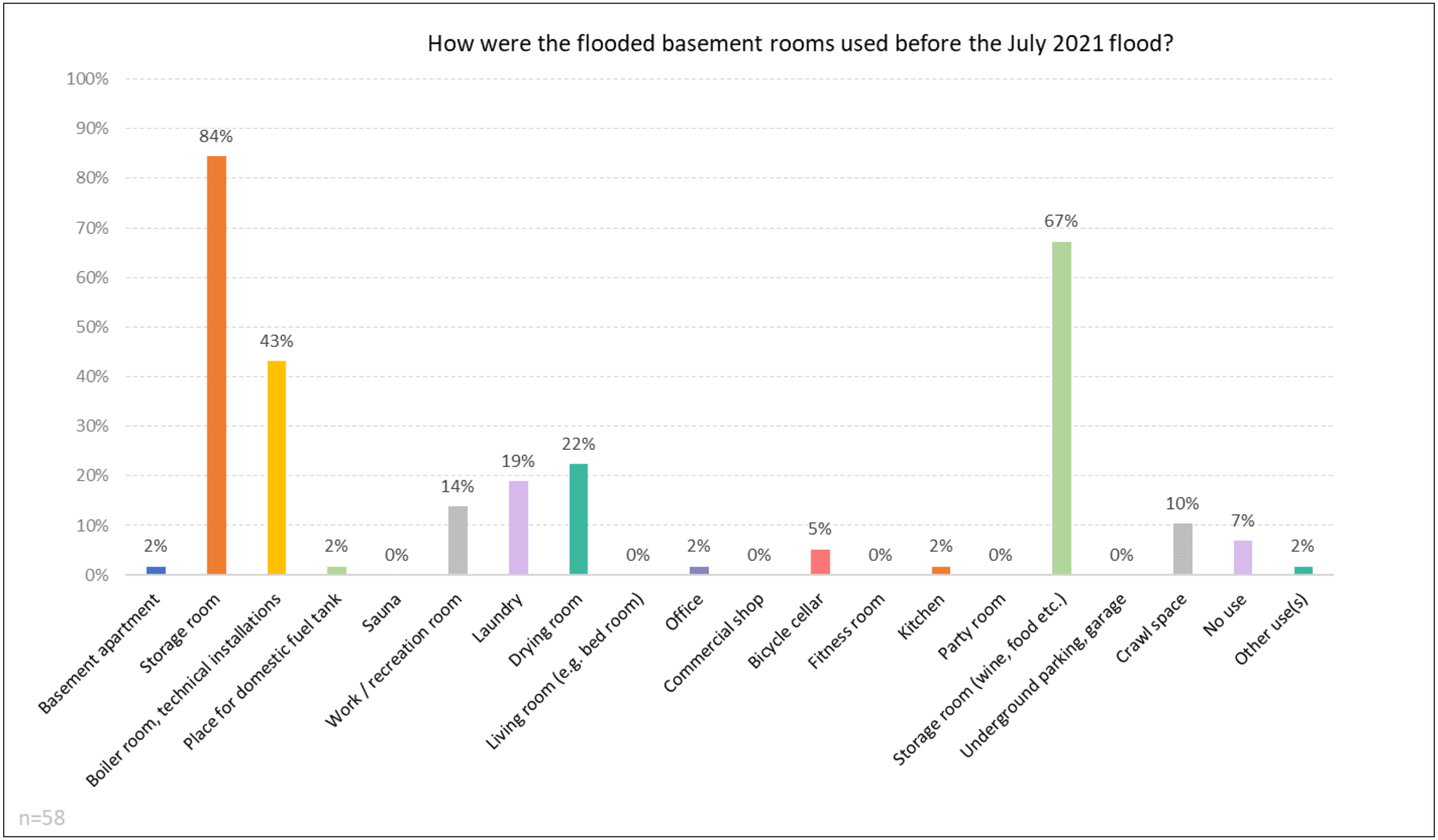



*Figure 155: Percentages of usage the basement had before the flood in July 2021, Belgium (questionnaire part 2 residential, question 31).*

*Table 9: Other uses of basement rooms before the flood in July 2021 than mentioned in question 31, Belgium (n=3) (questionnaire part 2 residential, question 32).*

| Abundance | Other uses of the basement rooms |
|---|---|
| 1 | Storage of personal items and boxes for moving |
| 1 | Tools |
| 1 | Bathroom |

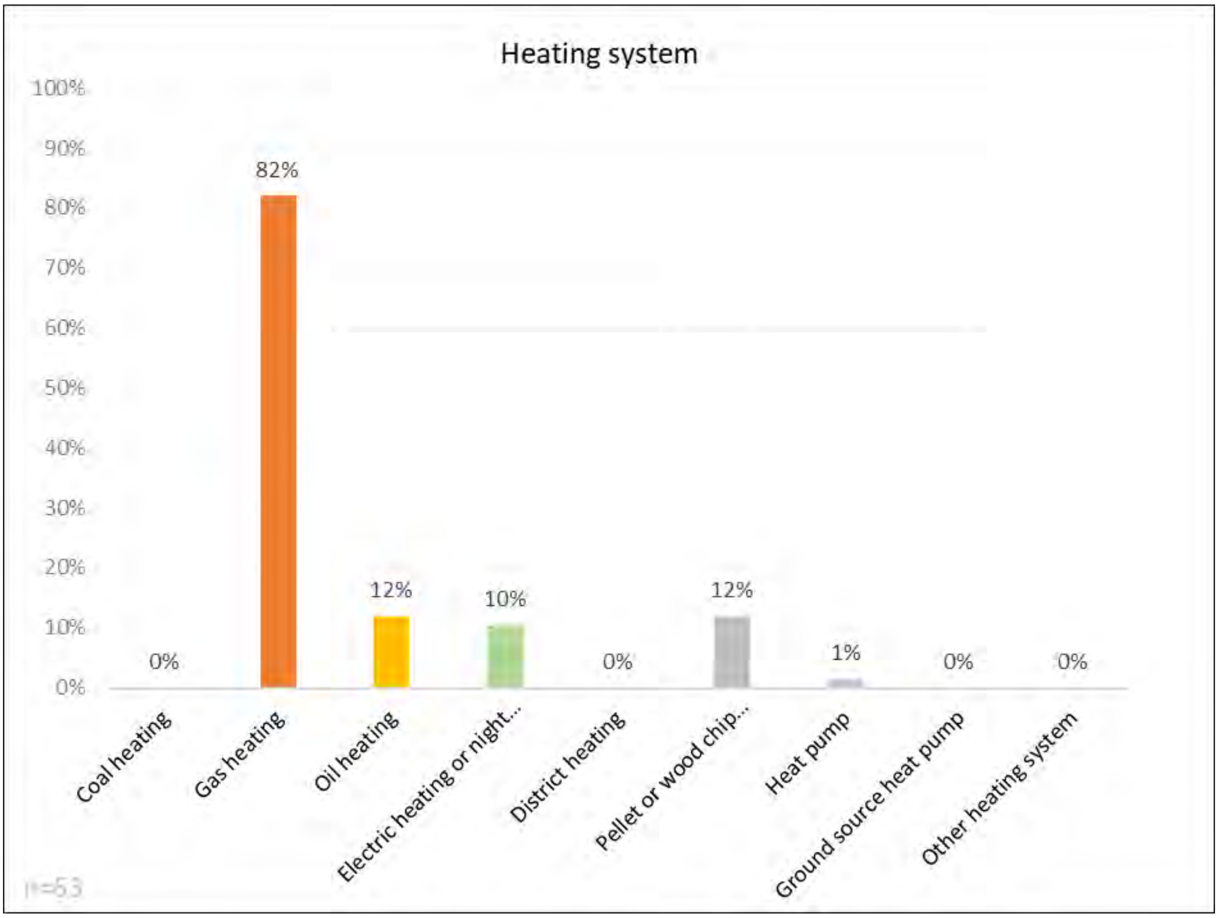



*Figure 156: Percentages of the heating systems of the participants, Belgium (questionnaire part 2 residential, question 35).*

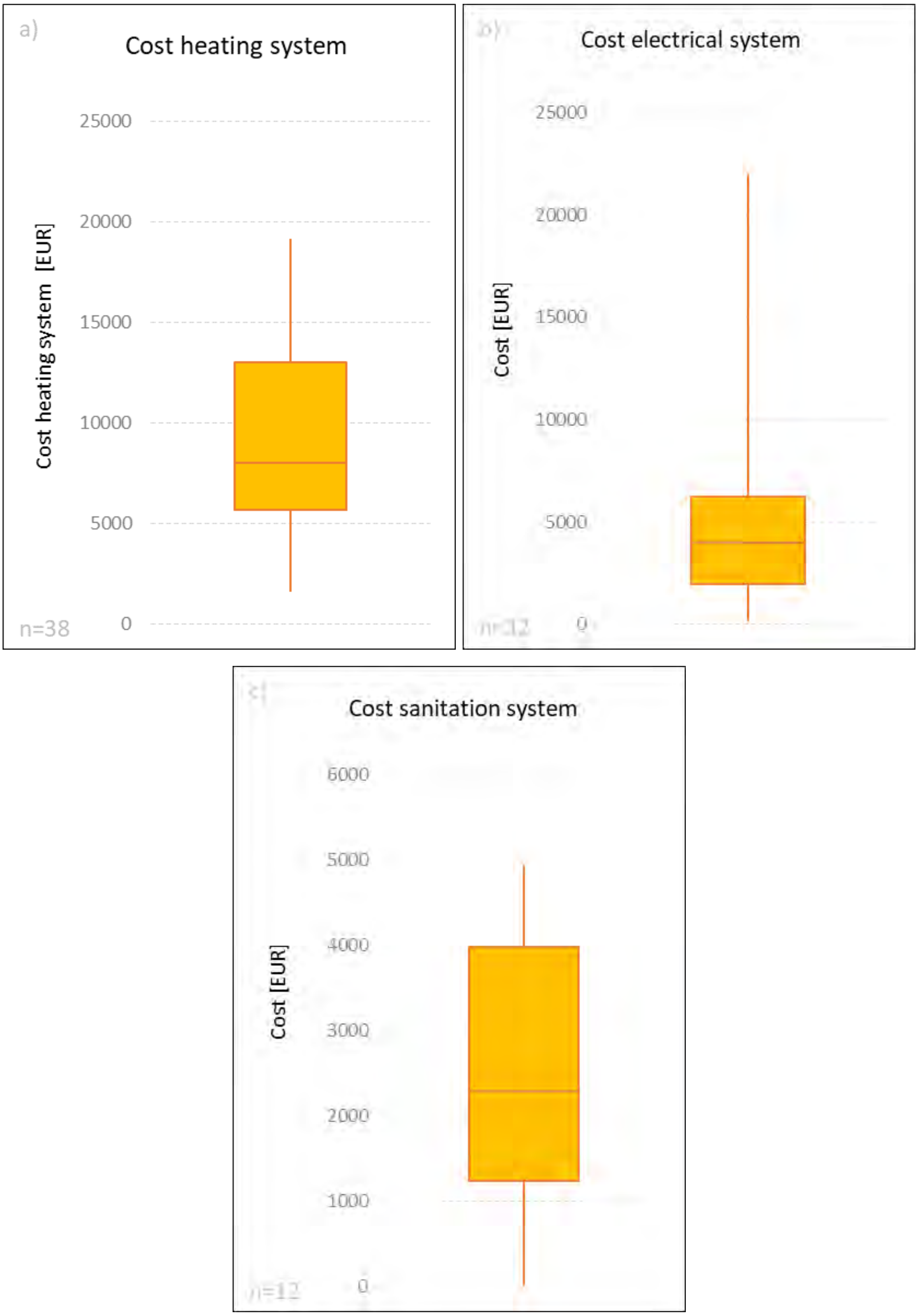



*Figure 157: Box plot of the total cost for repairing the a) heating system, b) electrical system and c) plumbing and sanitation system, Belgium (questionnaire part 2 residential, question 39-41).*

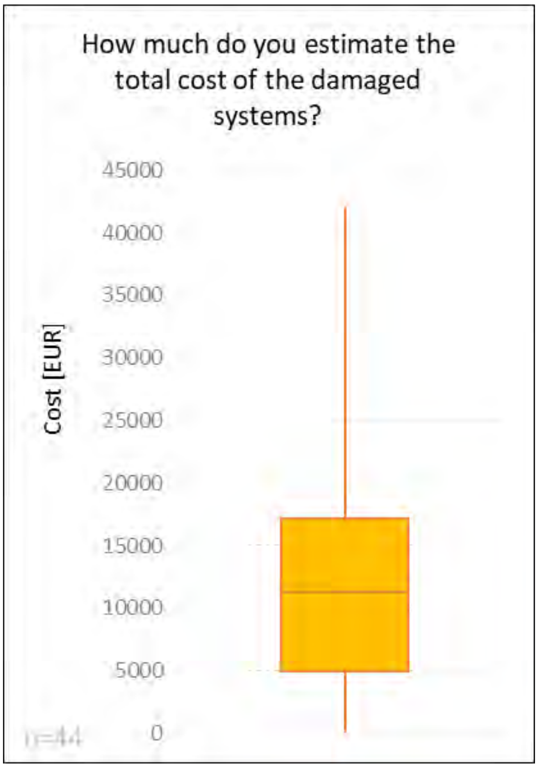



*Figure 158: Box plot of the total cost for repairing the damages systems, Belgium (questionnaire part 2 residential, question 42).*

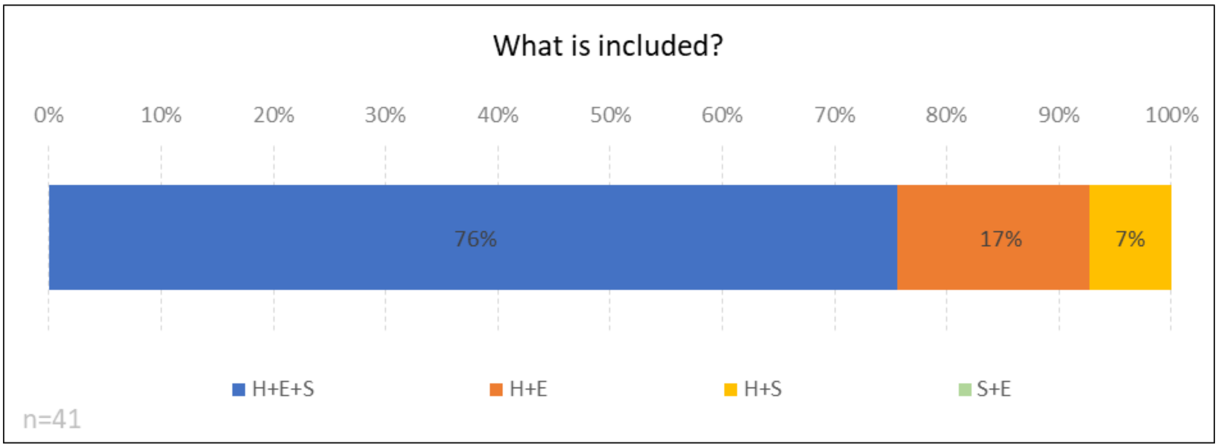



*Figure 159 : Percentage of which systems are included in the costs in question 42, Belgium; H : heating system, E : electrical system, S : sanitation and plumbing system (questionnaire part 2 residential, question 43).*

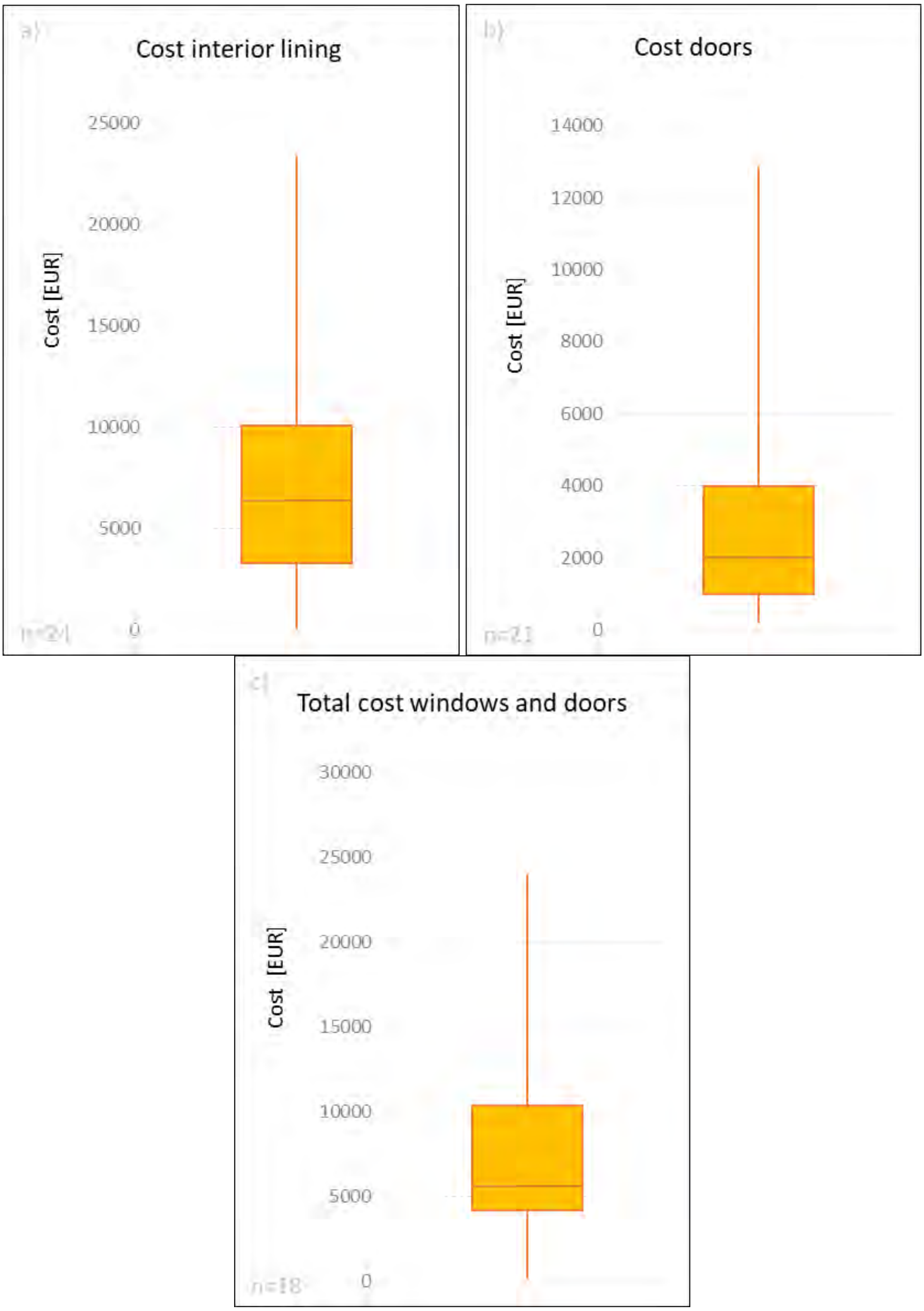



*Figure 160: Boxplots of the costs for a) interior lining, b) doors and c) windows and doors, Belgium (questionnaire part 2 residential, question 45, 47, 48).*

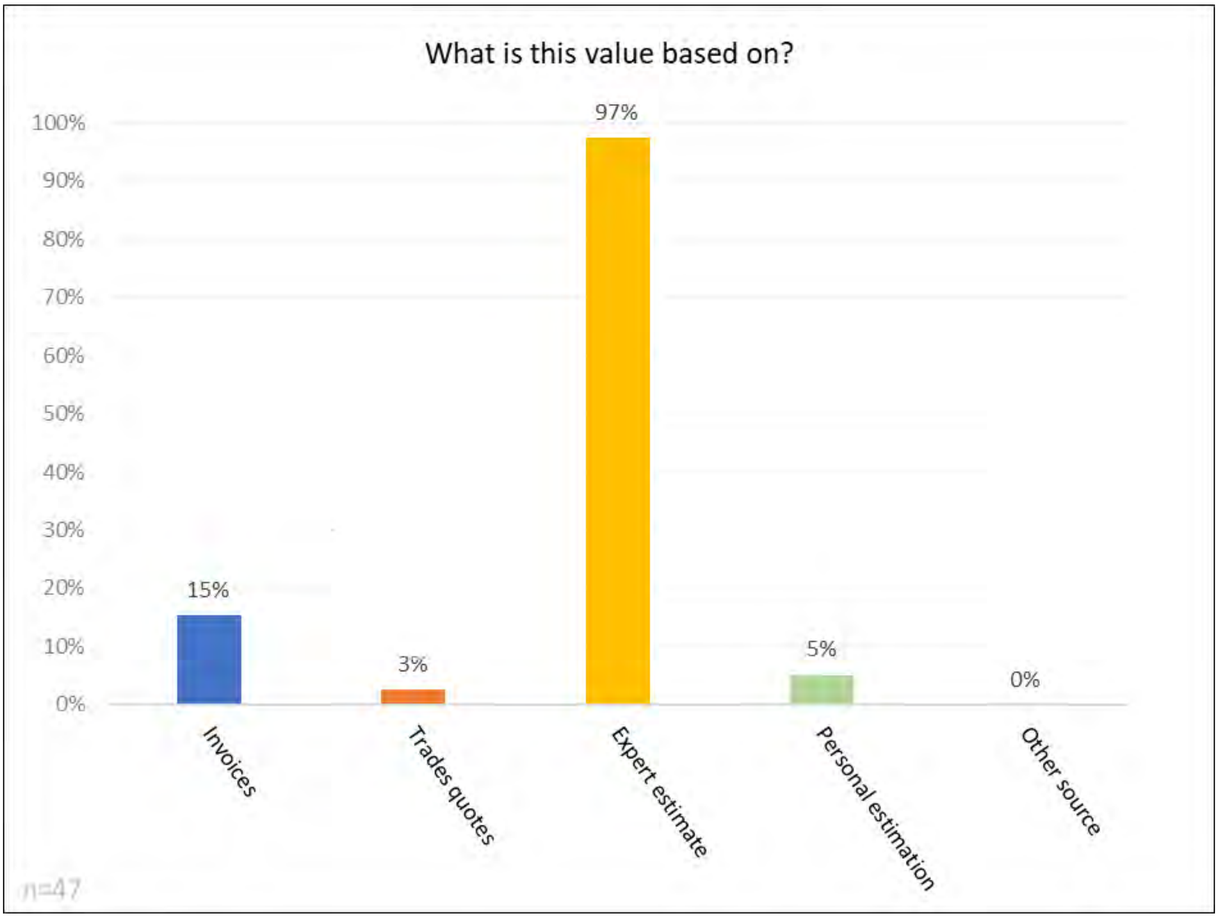



*Figure 161 : Percentages of basis for the given costs in question 50, Belgium (questionnaire part 2 residential, question 51).*


*Figure 162 : Boxplots of a) the hours for cleaning that were reported to the insurance and b) the financial compensation for the cleaning from the insurance, Belgium (questionnaire part 2 residential, question 55-56).*

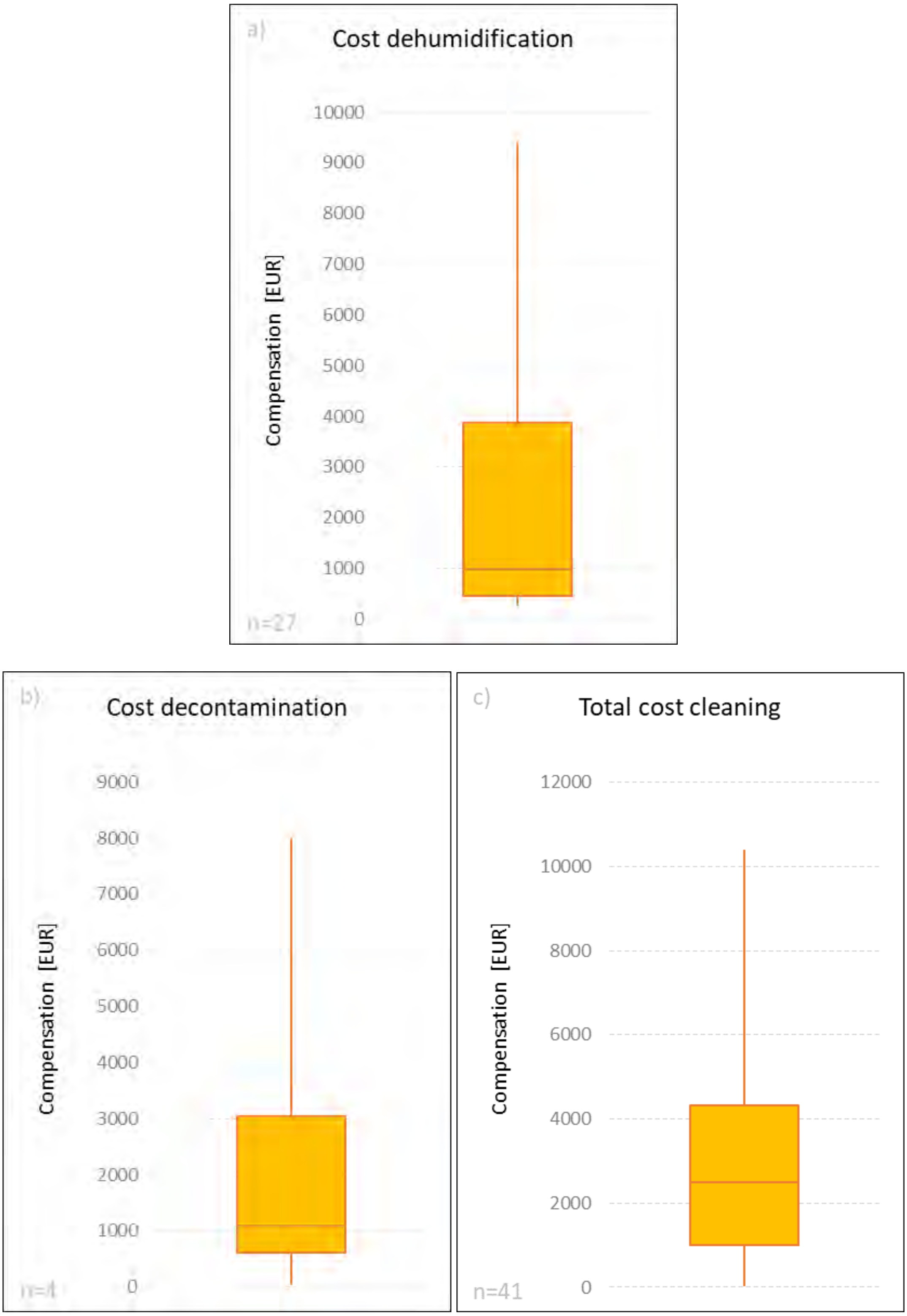



*Figure 163: Box plot of the costs for a) dehumidification, b) decontamination and c) cleaning in total, Belgium (questionnaire part 2 residential, question 57-59).*

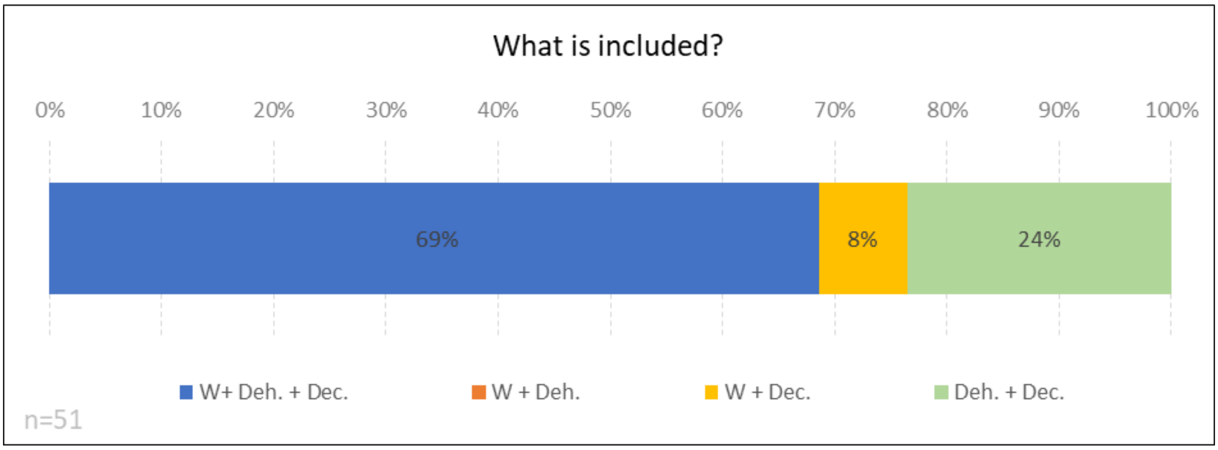



*Figure 164: Percentages of which costs are included in the value given in question 59, Belgium (questionnaire part 2 residential, question 60).*

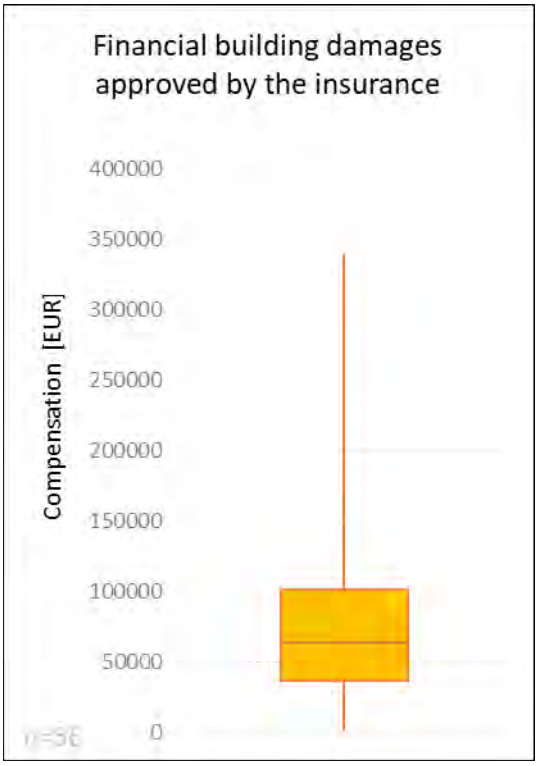



*Figure 165: Box plot of the approved amount of damage to or in the building by the insurance company, Belgium (questionnaire part 2 residential, question 61).*

*Table 10 : Other types of financial help than mentioned in question 66, Belgium (questionnaire part 2 residential, question 67).*

| Abundance | Other types of financial help |
|---|---|
| 43 | Rent reductions, energy bills, tax breaks etc. |
| 2 | Logis Vesdre |

*Table 11 : Needs, participants still had at the time of the interview, Belgium (questionnaire part 2 residential, question 74.)*

| Number | Which needs do you still have that have not yet been addressed? |
|---|---|
| 1 | Better reflection on developments and consideration on the scale of the whole valley and not occasional interventions. Respondents find that the punctual widening of the Vesdre bed is useless. |
| 2 | Recognize the twists committed. |
| 3 | The fact that the work is not finished and that the garden is no longer in condition, that the work has not started there and that the garden will therefore not be usable this summer because full of mud. |
| 4 | The person would have liked better compensation because in the precipitation one cannot remember everything that we have lost, so certain things are not considered in compensation. |
| 5 | Accelerate the work that takes time because of the owner |
| 6 | Aid for work, trades available things that are not counted in compensation |
| 7 | Finish finishing works |
| 8 | Loss of irreplaceable sentimental objects |
| 9 | Losing your house by expropriation. |
| 10 | Have concerning information the street expropriations, the period for demolition work |
| 11 | Support when carrying out reconstruction work and in the search for competent trades. |
| 12 | Finish the garage work, in particular the restoration work on the floor covering. |
| 13 | Humidity problems |

*Table 12: Things that could have been done better in terms of information/support from government/own capabilities, Belgium (questionnaire part 2 residential, question 75).*

| Number | What could have been done better in terms of information/support from government/ own capabilities? |
|---|---|
| 1 | Lack of transparency and information on the severity of the situation, no warning information before flood, or awareness. |
| 2 | Review insurance contracts for buildings under work |
| 3 | Review the management of the dam, hiring more competent people |
| 4 | Drain the Vesdre |
| 5 | The town was of great help (thank you) |
| 6 | There are too many abuses and profits on the back of the vulnerability of the victims |
| 7 | A more convincing alert |
| 8 | It was correct, she said. |
| 9 | Better dam management |
| 10 | More financial and human support on the part of governments |
| 11 | Alerte insufficient (only a police car early in the morning) |
| 12 | Lack of respect and consideration - acknowledging wrongs |
| 13 | Intervene for gardens (because 15,000 are not taken care of) - national rescue services were lacking at the beginning, because they were insufficient and unqualified - psychological support |
| 14 | Be more present (humanly and financially) |
| 15 | Take the warnings of specialists seriously |
| 16 | Satisfied with the actions of the municipality. |
| 17 | Maintenance of the rivers to plan and lack of clarity on the seriousness of the floods, the authorities were not persuasive enough on the danger at the time of the flood and the evacuation. |

| | |
|---|---|
| 18 | Don't make the victims suffer a double penalty: they've already suffered flooding, so their property has already lost value (they can't resell it without loss), and they don't want to see their house put in a "non-constructible" zone because of the risk of flooding. |
| 19 | Take into account garden furniture systematically in insurance contracts. |
| 20 | Increase compensation, reduce taxes, do not minimize the severity of the flood, and consider more forecast. |
| 21 | Improve the infiltration upstream, in the Fagnes, to avoid the torrential flow they mentioned downstream. Decrease the waterproofing of soil and urbanization. |
| 22 | The government should have clearly issued an evacuation order, few people were evacuated, and no information was given in the crisis. |
| 23 | Maintenance of the rivers, not doing work on the place that increases runoff, cleaning systems |
| 24 | Maintenance of the rivers, not doing work on the place that increases runoff, cleaning systems |
| 25 | Do everything possible to prevent floods from happening again - Lack of warning when disaster strikes |
| 26 | More precise prevention that tells people what areas are really at risk before the flood, as the information communicated was too general. It has to be made clear where the flooding will take place and what the specific degree of risk is, otherwise, people can't realize the risk they're running and react appropriately. Lack of communication on hazard maps; they need to be explained and information provided about them. |
| 27 | Clean up the rivers, be stricter about river maintenance - Lift and repair low walls along the river. Don't forget Juslenville, don't always think of Theux first. |
| 28 | Clean up the rivers, maintain them better to reduce the water level, even if this won't prevent flooding. Don't build new buildings on the only remaining green space in the neighbourhood, and don't waterproof new soils in the surrounding area, as this will worsen the situation. |
| 29 | Keep your promises and not expropriate people who have already suffered sufficiently with flood. Do not wait 1 year to warn that they are going to be expelled because in the meantime, they have spent 1 year doing reconstruction work, that they pay and for which they have invested time, all for nothing in the end - relation to the services of the Red Cross. |
| 30 | Alerting your citizens to the risks involved. |
| 31 | To better manage coordination with insurers, who were overwhelmed. |
| 32 | Better alert |
| 33 | The government has done nothing, they are liars, there are people who are still in need and the government does nothing to help them. |
| 34 | Bad management by the emergency services due to the bad weather, but the services should be trained to intervene in much more complicated situations than that, so that doesn't justify their shaky management of the situation. The army intervened with derisory means, not even boats, and misplaced human resources since the army was placed in aid of the Red Cross for the distribution of meals even though there was still a lot of work for which their arms would have been more useful. |
| 35 | Arrange the banks, take the gardens into account + tools |
| 36 | Psychological support - helping the disabled and elderly - alerting and warning of evacuation |
| 37 | Improve dam management |
| 38 | Improve dam management |
| 39 | No follow -up after the flood, no one talks about it anymore |

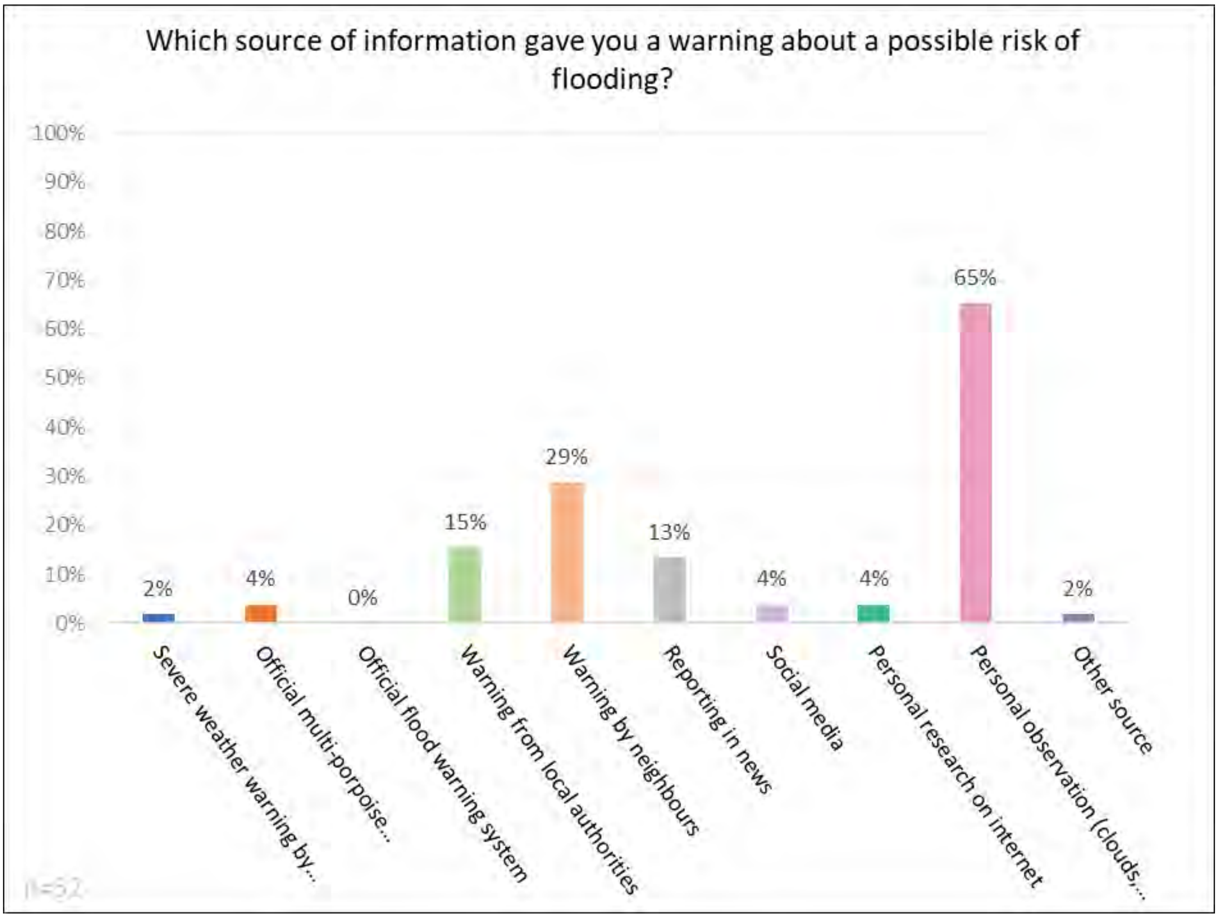



*Figure 166 : Percentages of warning sources, from which the participants received a warning about the possible risk of flooding, Belgium (questionnaire part 2 residential, question 77).*

*Table 13 : Other warning sources than mentioned in question 77, Belgium (questionnaire part 2 residential, question 78).*

| Abundance | Other warning sources |
|---|---|
| 1 | Militars passed at 19h |

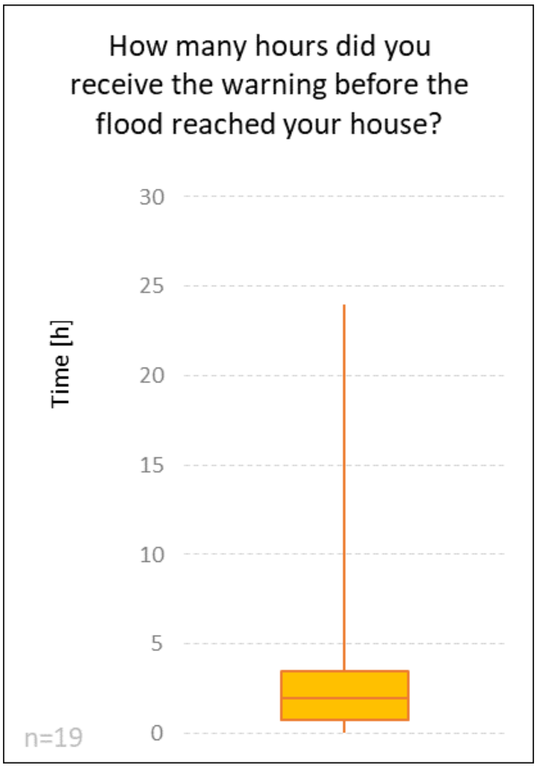



*Figure 167: Box plot of hours before the flood reached the participants house, Belgium (questionnaire part 2, question 79).*

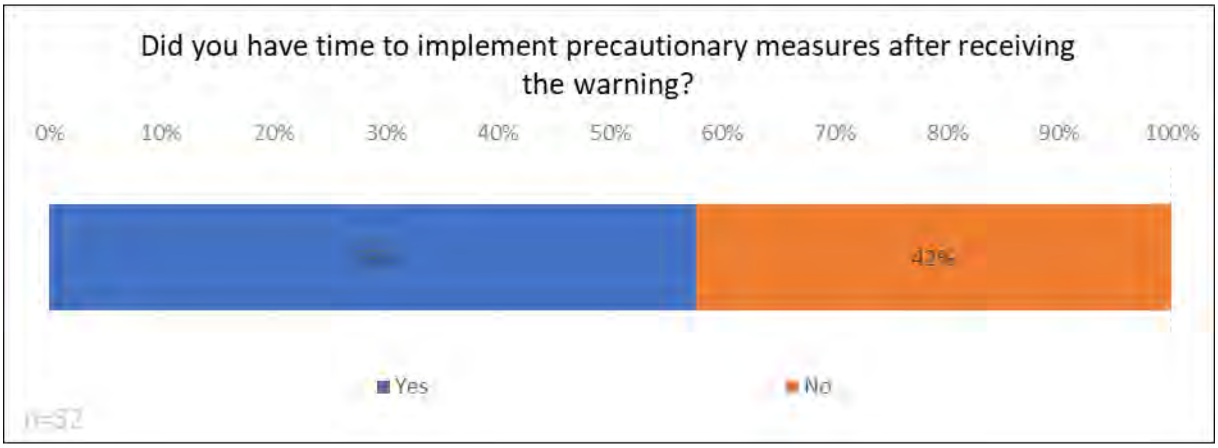



*Figure 168: Percentages of people who had time to implement precautionary measures after receiving the warning or not, Belgium (questionnaire part 2 residential, question 80).*

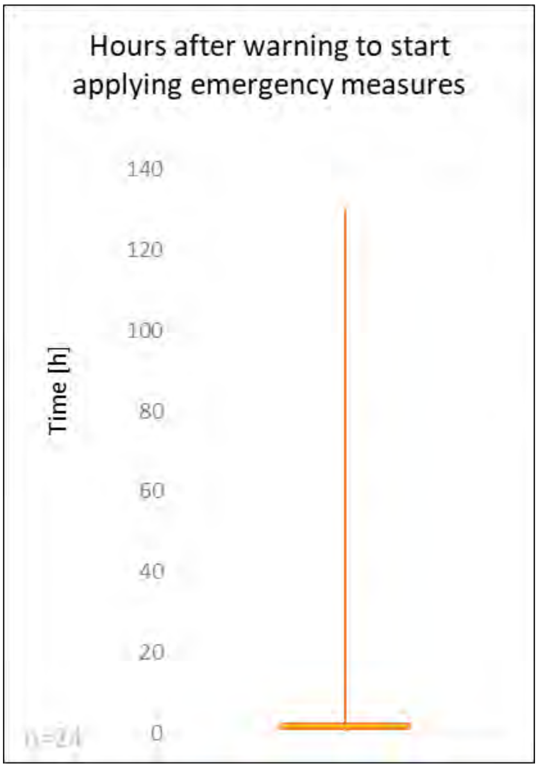



*Figure 169: Box plot of hours participants started applying emergency measures after receiving a warning, Belgium (questionnaire part 2 residential, question 81).*

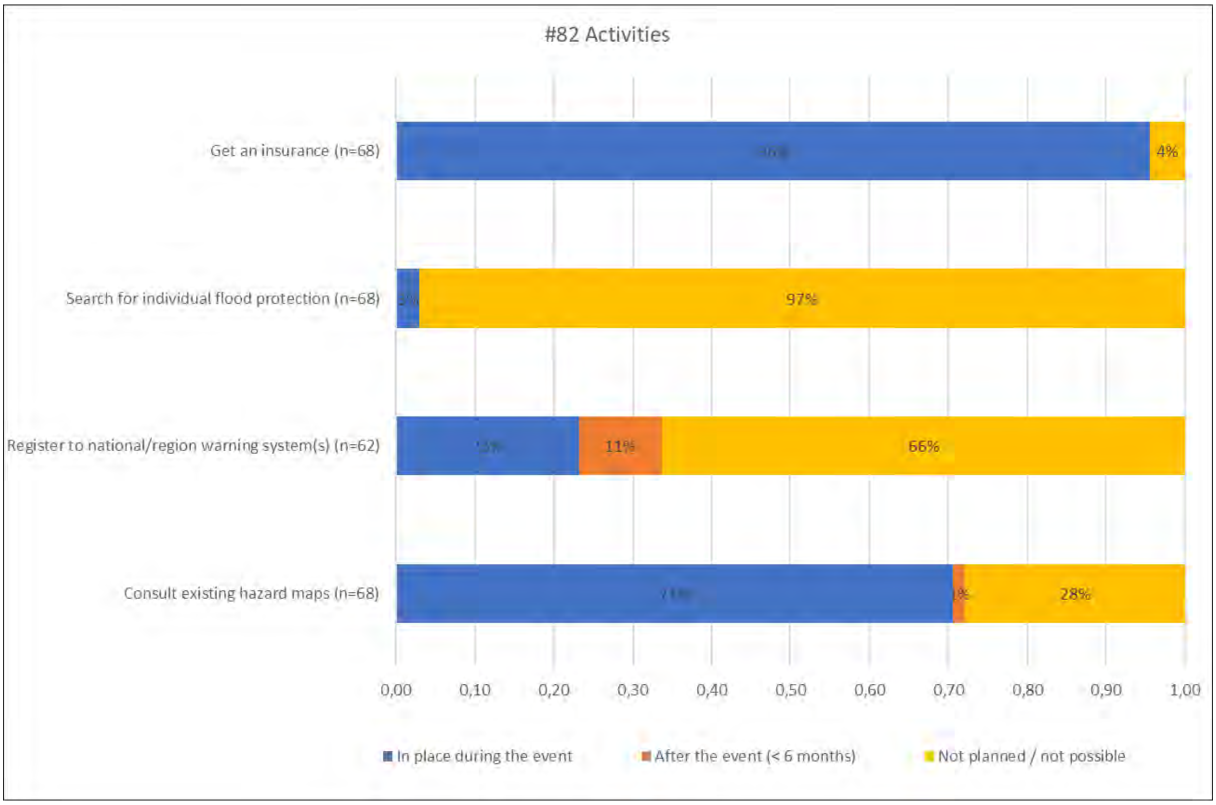



*Figure 170: Percentages of activities to be better informed of what to do in case of flood, Belgium (questionnaire part 2 residential, question 82).*

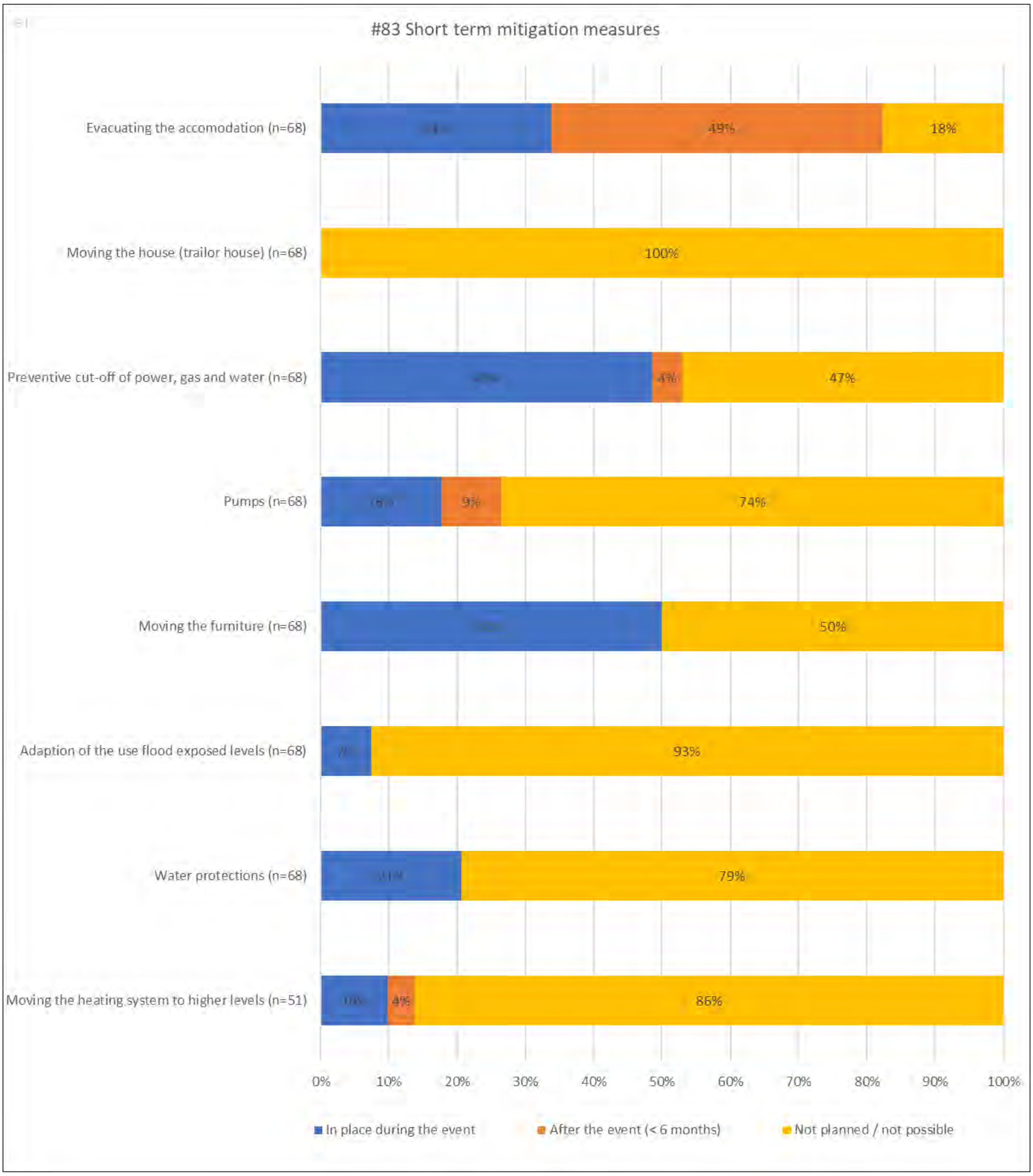
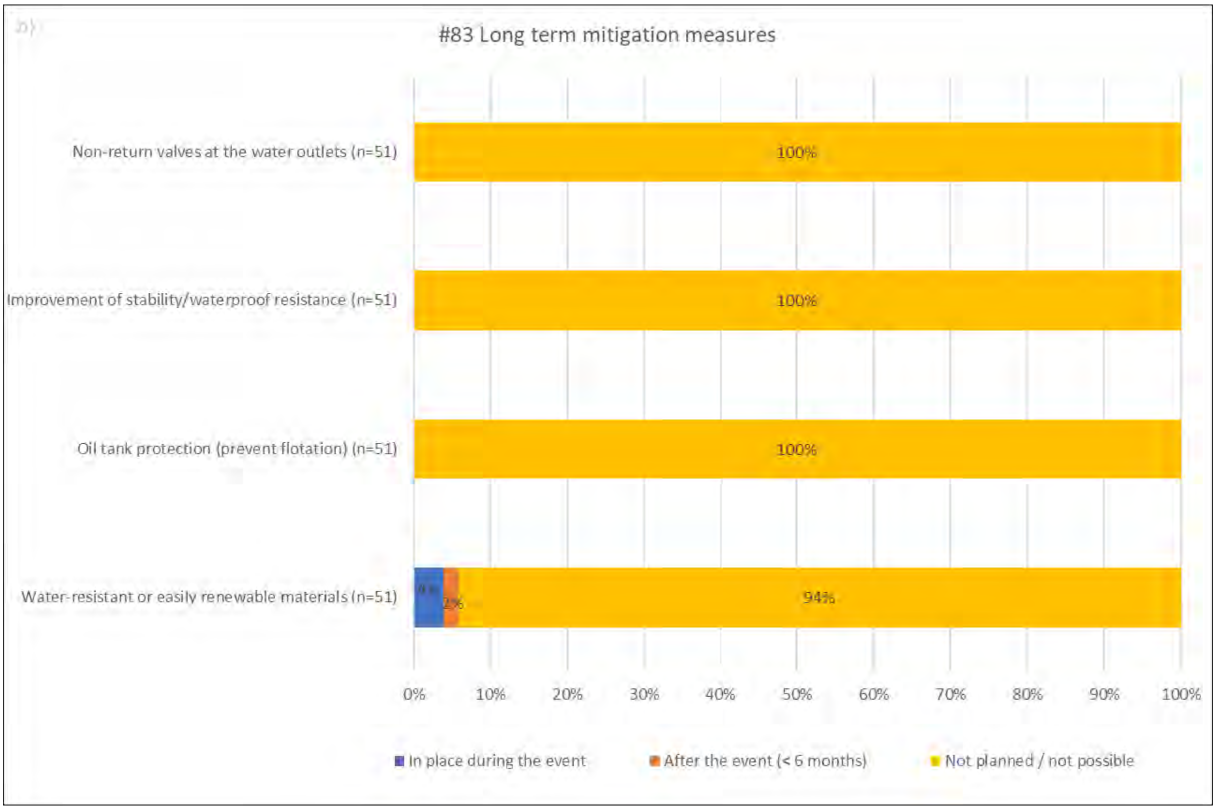



*Figure 171: Percentage of a) short term mitigation, b) long term mitigation measures, Belgium (questionnaire part 2 residential, question 83).*


#83 Long term mitigation measures
Non-return valves at the water outlets (n=51)
Improvement of stability/waterproof resistance (n=51)
Oil tank protection (prevent flotation) (n=51)
Water-resistant or easily renewable materials (n=51)
100%
100%
100%
2%
94%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
In place during the event
After the event (< 6 months)
Not planned / not possible

# Germany

## Survey statistics

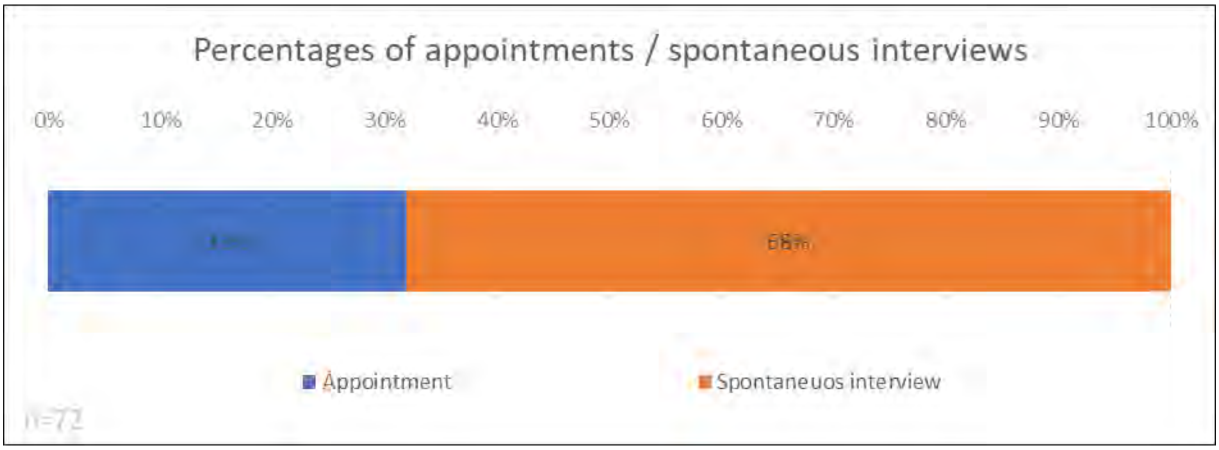



*Figure 172: Percentages of appointments/spontaneous interviews, Germany.*

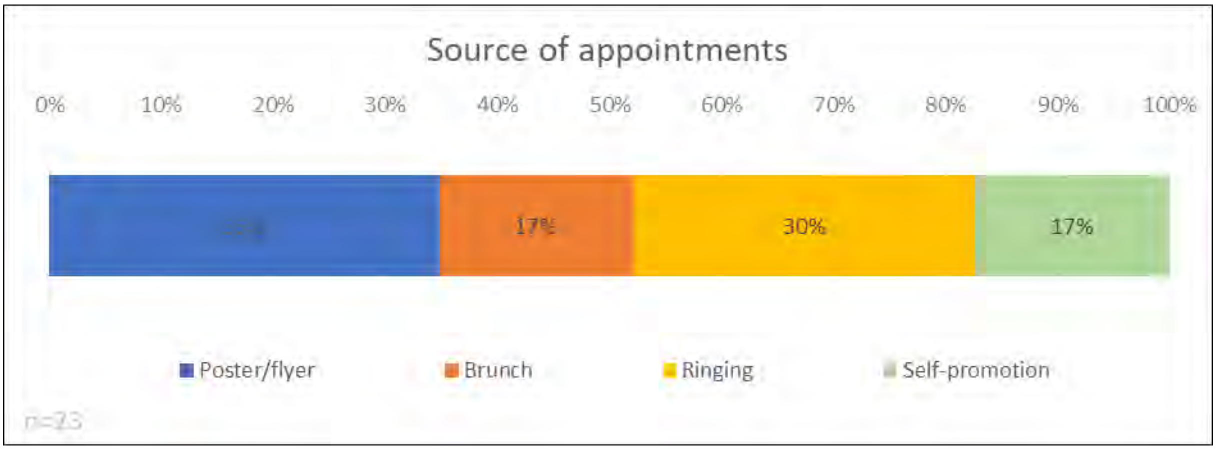



*Figure 173: Source of appointments, Germany.*

## Part 1

*Table 14: List of other recorded socio-professional categories than available in question 11 and their abundance, Germany (questionnaire part 1, question 13).*

| Abundance | Other socio-professional categories |
|---|---|
| 1 | Social pedagogue |
| 1 | Professional soldier |
| 2 | Core Worker |
| 3 | Teacher |
| 1 | In training |
| 1 | Employee at butcher shop |
| 5 | Housewife |
| 1 | Graphic designer |
| 1 | Fire fighter |
| 1 | Toolmaker |
| 1 | Head of kindergarten |
| 1 | Traffic assistant |
| 1 | Pharmacy employee |
| 1 | Both, self-employed & employed, office and manual worker |

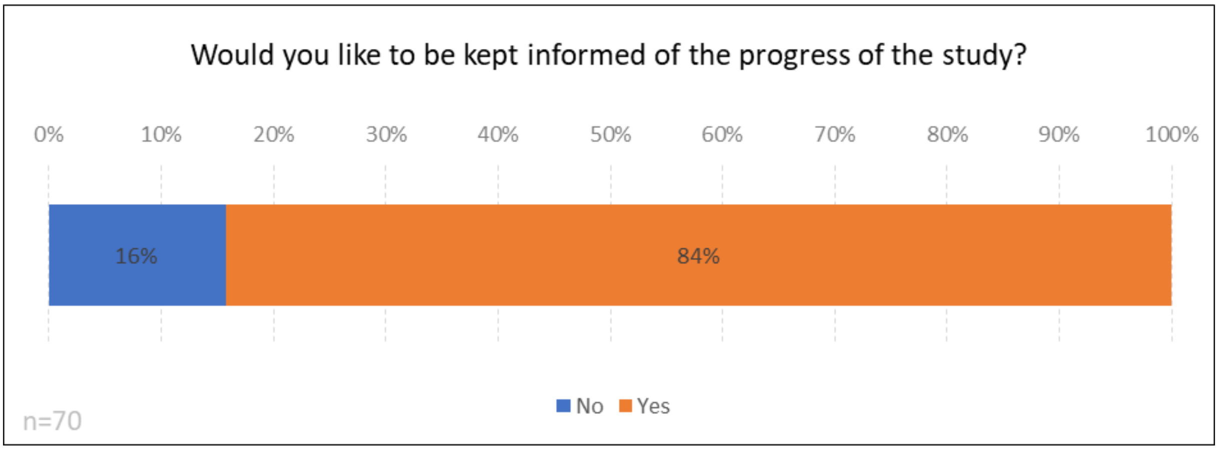



*Figure 174: Percentages of people who would like to be kept informed of the progress of the study, Germany (questionnaire part 1, question 13).*

## Part 2 residential

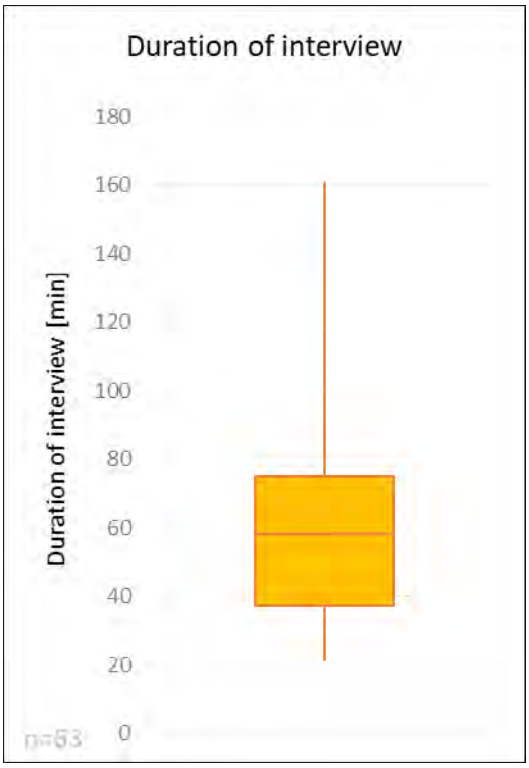



*Figure 175: Boxplot of the interview durations, Germany (questionnaire part 2 residential, questions 1 & 87).*

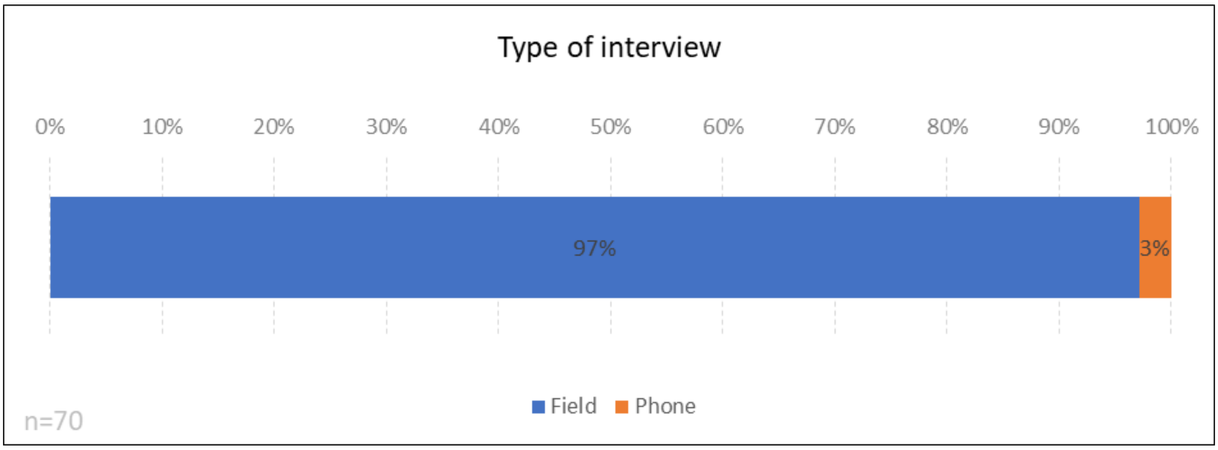



*Figure 176 : Percentage of the interview type, Germany (questionnaire part 2 residential, question 2)*

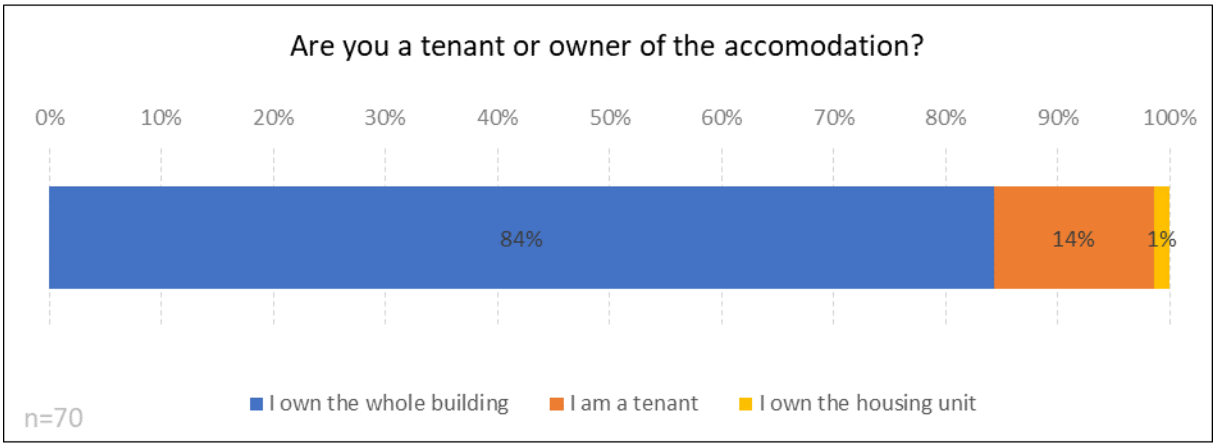



*Figure 177: Percentages of the participants who are owners or tenants of their home, Germany (questionnaire part 2 residential, question 4).*

*Table 15: List of other recorded causes of flooding, Germany (n=13, questionnaire part 2 residential, question 6).*

| Abundance | Other causes of flooding |
|---|---|
| 1 | Overflow of the dam in Belgium/Rurtalsperre |
| 7 | "Dreilägerbachdam was opened" |
| 1 | Dreilägerbachdam was too full |
| 3 | Dreilägerbachdam was mismanaged |
| 1 | Undefineable |
| 2 | Dreilägerbachdam was opened too late |
| 1 | Perlenbachdam was opened too late |
| 1 | Uncontrolled discharge of the Dreilägerbachdam |

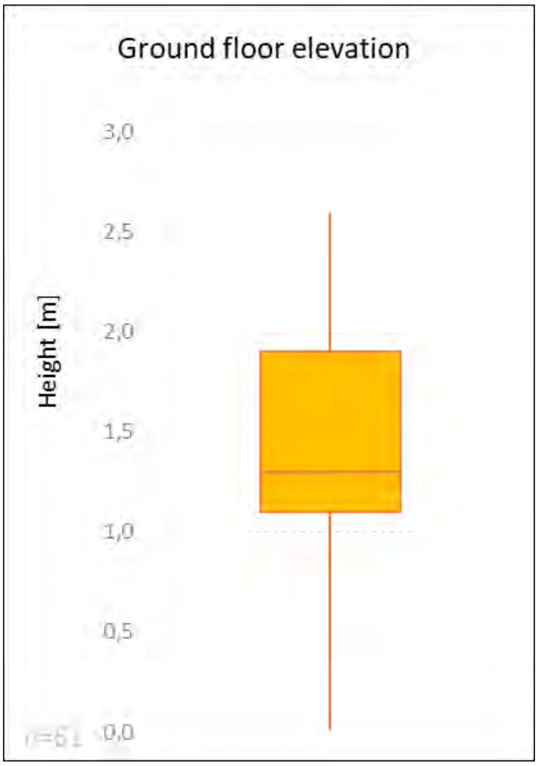



*Figure 178: Box plot of the elevation between street level and the ground floor of the buildings, Germany (questionnaire part 2 residential, question 8).*

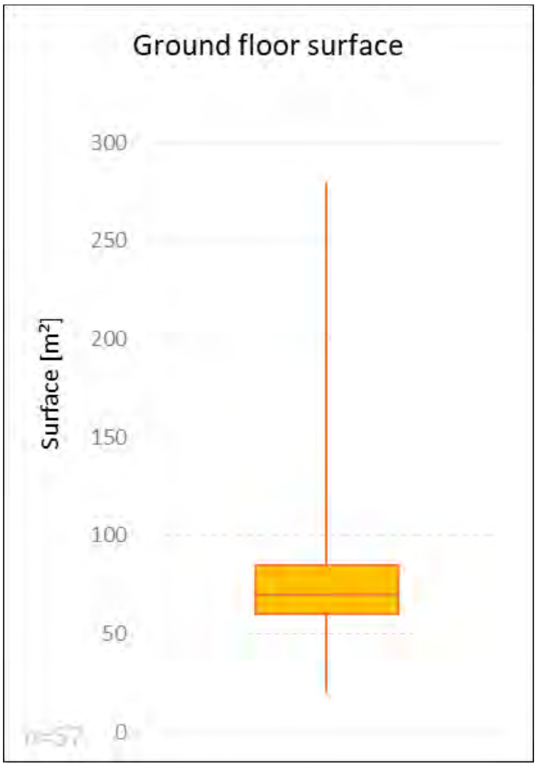



*Figure 179: Box plot of the sizes of the ground floor areas of the participants homes, Germany (questionnaire part 2 residential, question 15).*

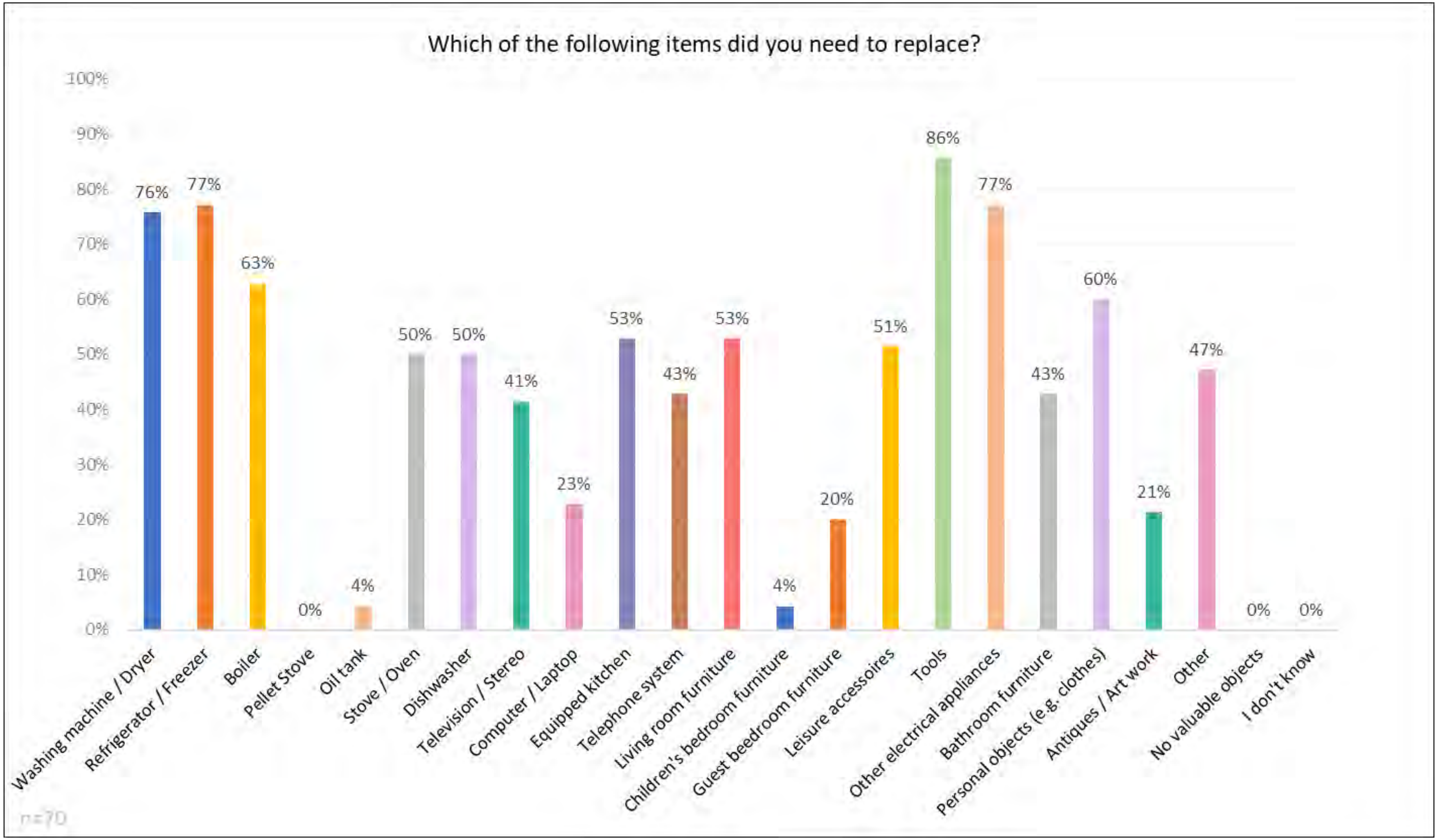



*Figure 180: Percentages of the household items, the participants did need to replace, Germany (questionnaire part 2 residential, question 16).*

*Table 16: Other voluminous/expensive items than available in question 16, Germany (questionnaire part 2 residential, question 17).*

| Abundance | Other voluminous/expensive items |
|---|---|
| 3 | (Massive) garden house with content |
| 5 | Food supplies |
| 2 | Expensive carpet(s) |
| 4 | Photos |
| 1 | Old record player |
| 3 | Record collection |
| 1 | Liquid gas tank |
| 1 | Expensive equipment for sled dogs |
| 1 | Professional construction equipment |
| 3 | Sauna |
| 3 | Piano |
| 1 | Motorcycle spare party |
| 2 | Wine collection |
| 1 | Jacuzzi |
| 1 | Wedding dress |
| 1 | Professional photographic equipment |
| 2 | Trailer |
| 1 | Office equipment |
| 1 | Furniture from private practice |
| 2 | Important files/documents (private/business) |
| 1 | Greenhouse |
| 1 | Jewellery |
| 2 | Toys |
| 1 | Garden furniture |
| 1 | Iron boar |
| 1 | Large plant buckets |
| 1 | Company server cabinet |
| 1 | Collection of old moulding planes |
| 1 | Gym equipment |
| 1 | Flee market items |
| 1 | Pumps |
| 1 | Camping table |

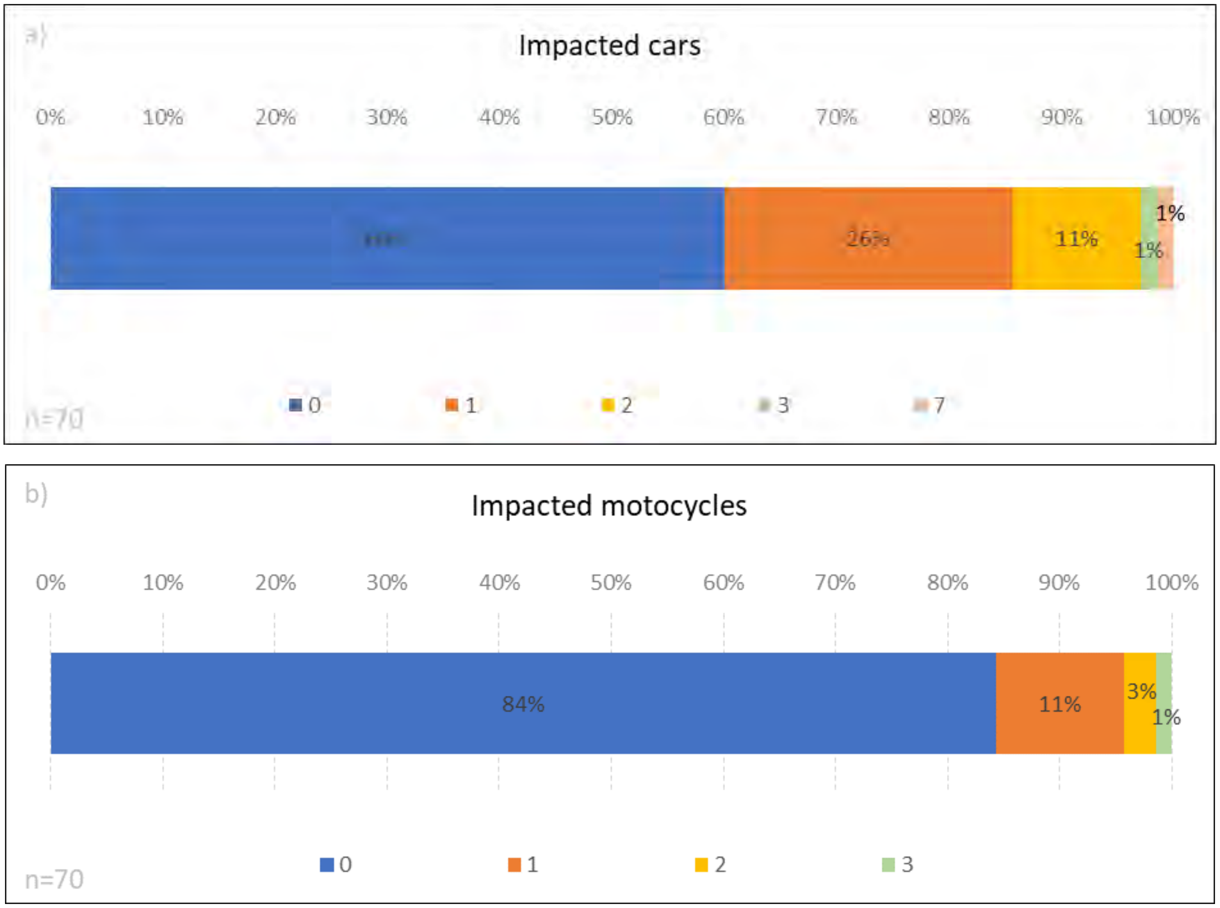



*Figure 181: Percentages of participants who had a) one/several car(s) or b) one/several motorcycles impacted by the flood, Germany (questionnaire part 2 residential, question 18).*

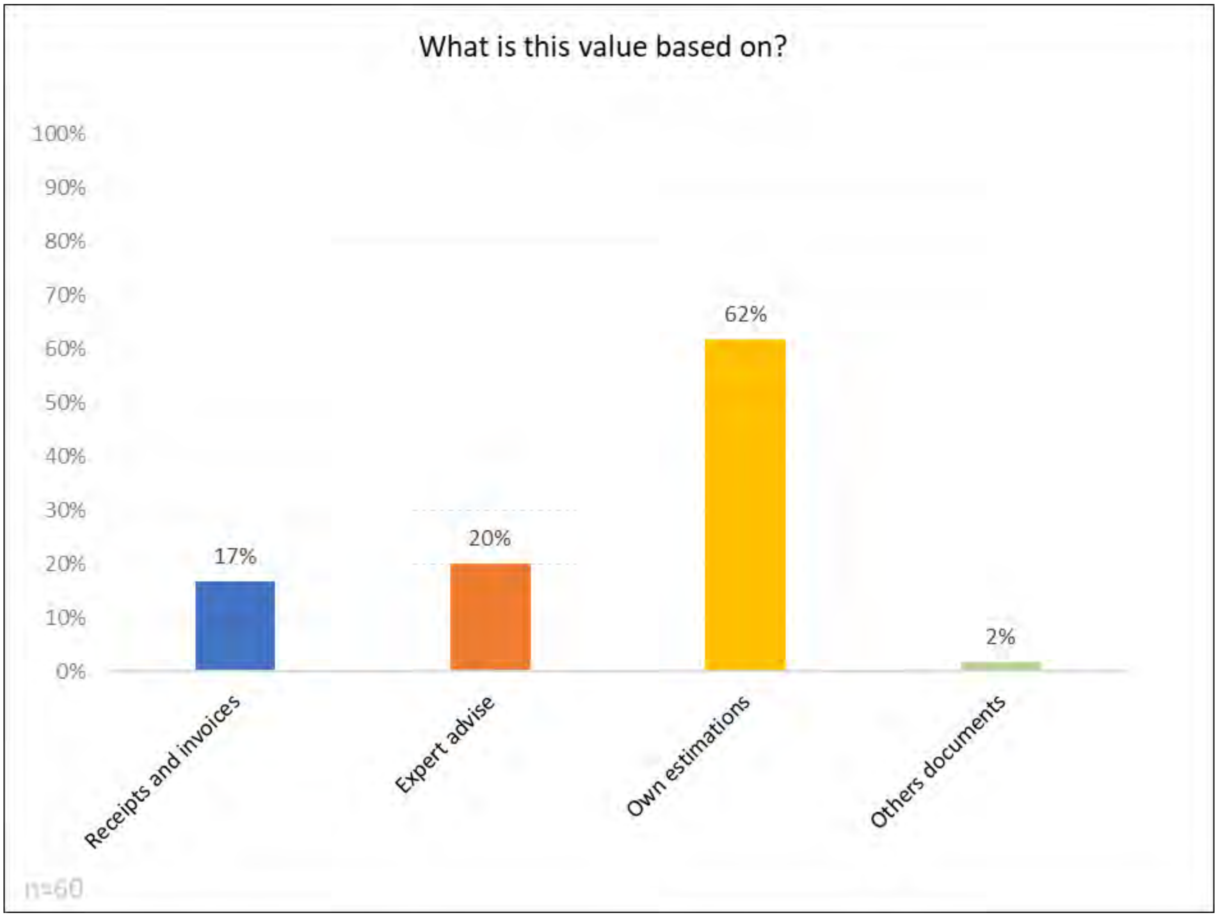



*Figure 182: Percentages of the base of the values from question 19, Germany (questionnaire part 2 residential, question 20).*

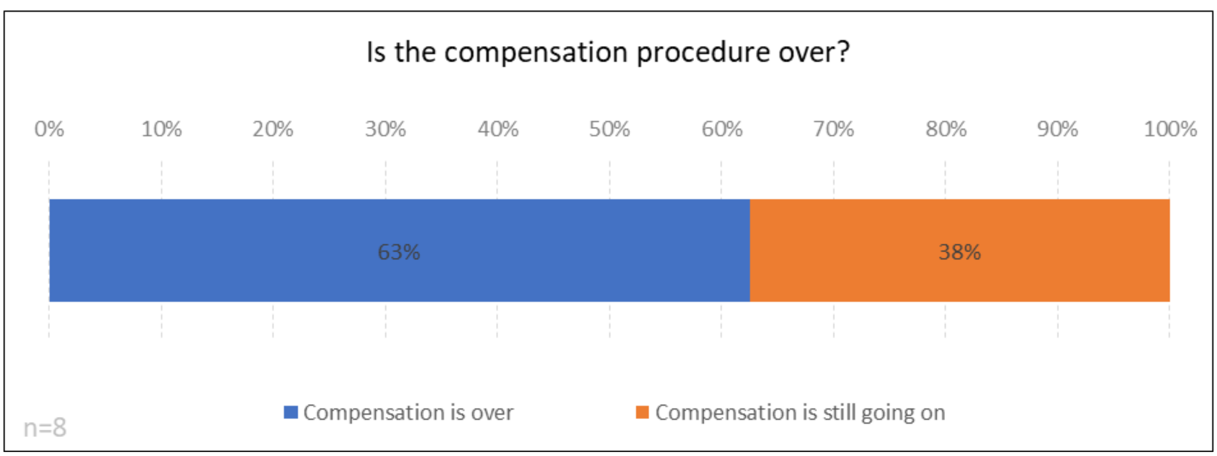



*Figure 183: Percentages of participants, whose compensation procedure of the damaged household items is over or not over, Germany (questionnaire part 2 residential, question 23).*

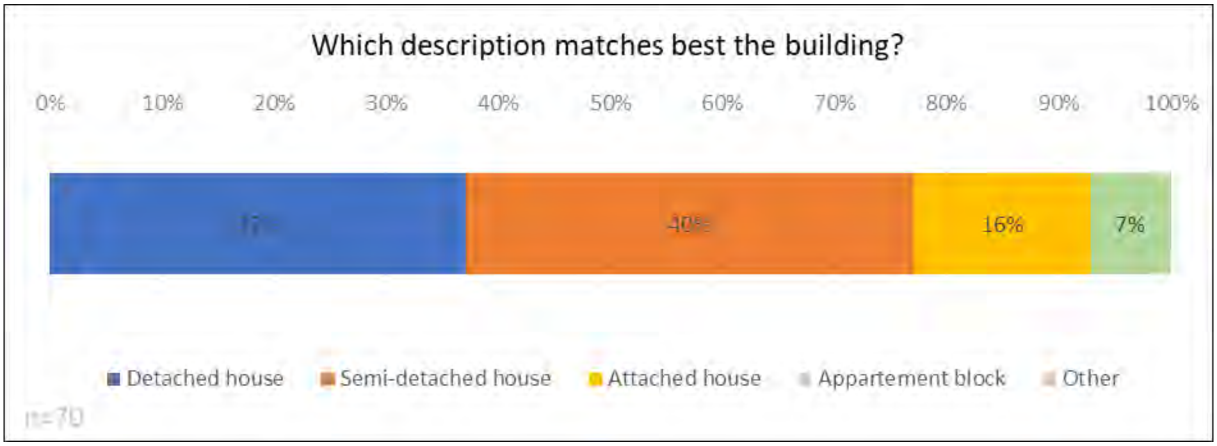



*Figure 184: Percentage of which types of buildings the participants live in, Germany (questionnaire part 2 residential, question 26).*

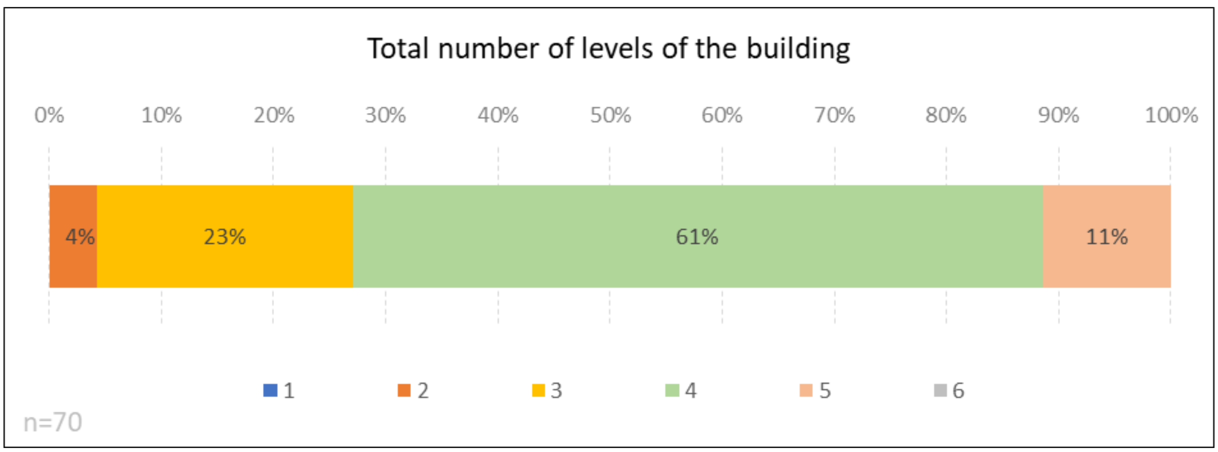
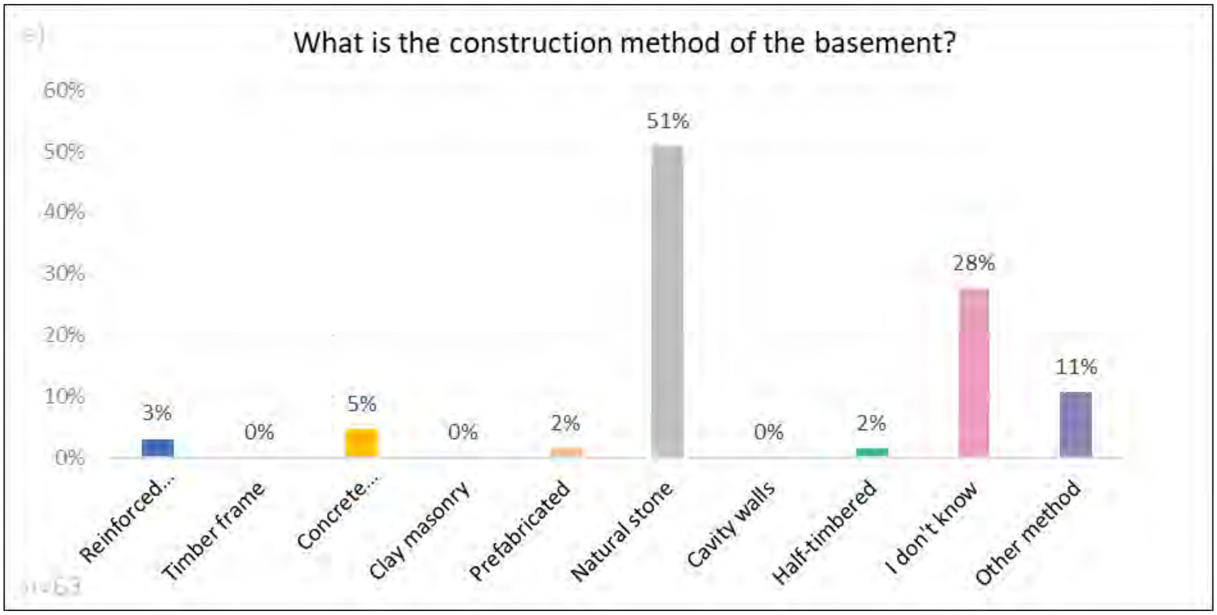
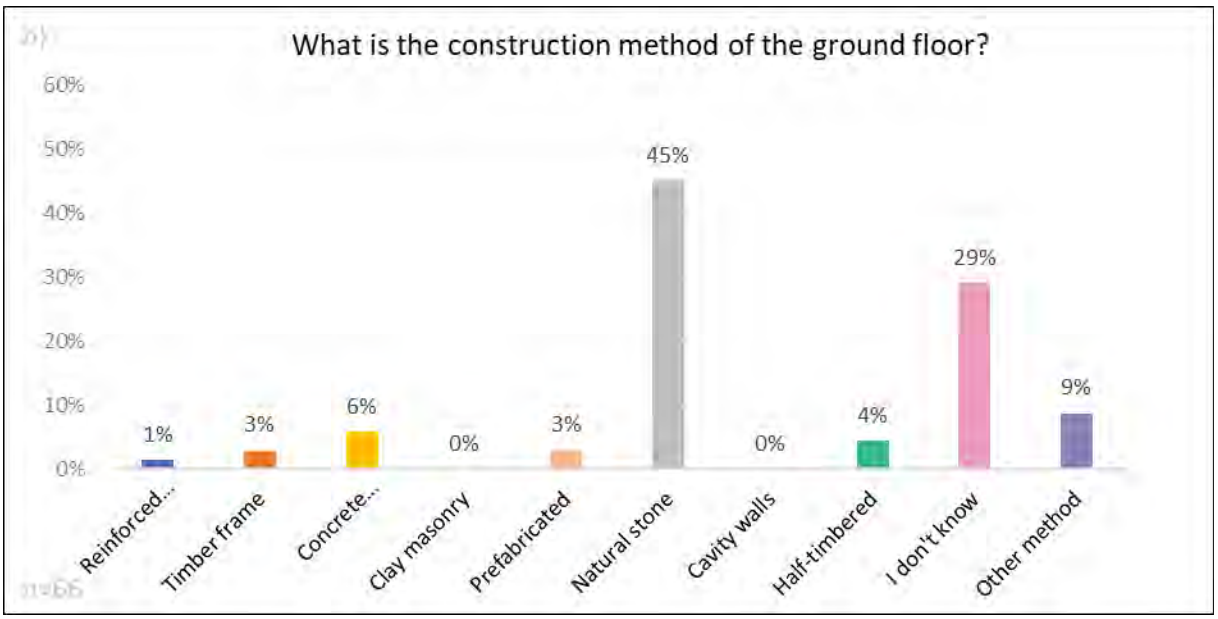



*Figure 185: Total number of levels of the buildings the participants live in, Germany (questionnaire part 2 residential, question 28).*


What is the construction method of the basement?
60%
50%
40%
30%
20%
10%
0%
3%
0%
5%
0%
2%
51%
0%
2%
28%
11%
Reinforced...
Timber frame
Concrete...
Clay masonry
Prefabricated
Natural stone
Cavity walls
Half-timbered
I don't know
Other method


What is the construction method of the ground floor?
60%
50%
40%
30%
20%
10%
0%
1%
3%
6%
0%
3%
45%
0%
4%
29%
9%
Reinforced...
Timber frame
Concrete...
Clay masonry
Prefabricated
Natural stone
Cavity walls
Half-timbered
I don't know
Other method

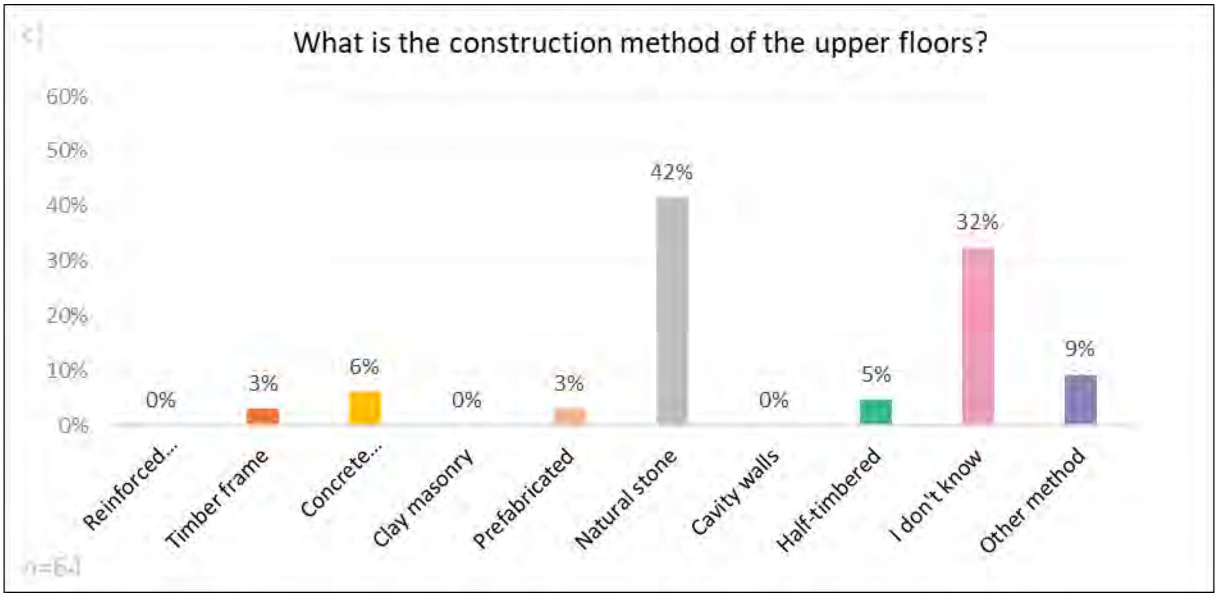



*Figure 186: Percentages of the construction methods of the a) basement, b) ground floor and c) upper floors of the buildings the participants live in, Germany (questionnaire part 2 residential, question 29).*

*Table 17 : Other building methods than mentioned in question 29 of the a) basement, b) ground floor and c) upper floors, Germany (questionnaire part 2 residential, question 30).*

a)

| Abundance | Other building methods basement |
|---|---|
| 2 | Perforated bricks |
| 4 | Brick masonry |
| 3 | Sand-limestone masonry |
| 3 | Brick masonry |
| 1 | Pumice masonry |

b)

| Abundance | Other building methods ground floor |
|---|---|
| 2 | Perforated bricks |
| 3 | Sand-limestone masonry |
| 4 | Brick masonry |
| 1 | Pumice masonry |

c)

| Abundance | Other building methods upper floor |
|---|---|
| 2 | Perforated bricks |
| 3 | Sand-limestone masonry |
| 2 | Brick masonry |
| 1 | Pumice masonry |

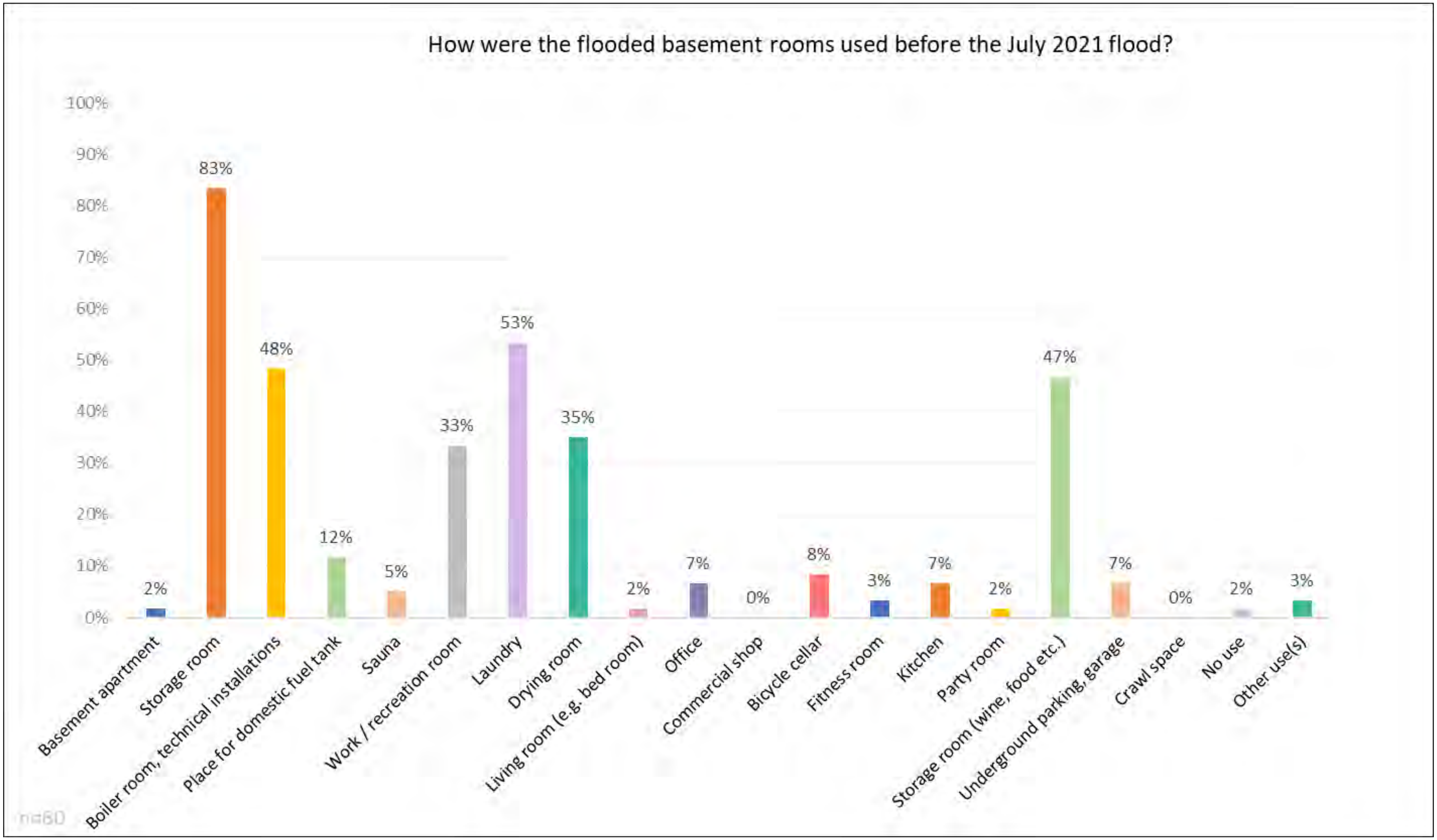



*Figure 187: Percentages of usage the basement had before the flood in July 2021, Germany (questionnaire part 2 residential, question 31)*

*Table 18: List of other uses of basement rooms before the flood in July 2021, Germany (questionnaire part 2 residential, question 32).*

| Abundance | Other uses of the basement rooms |
|---|---|
| 1 | Bathroom |

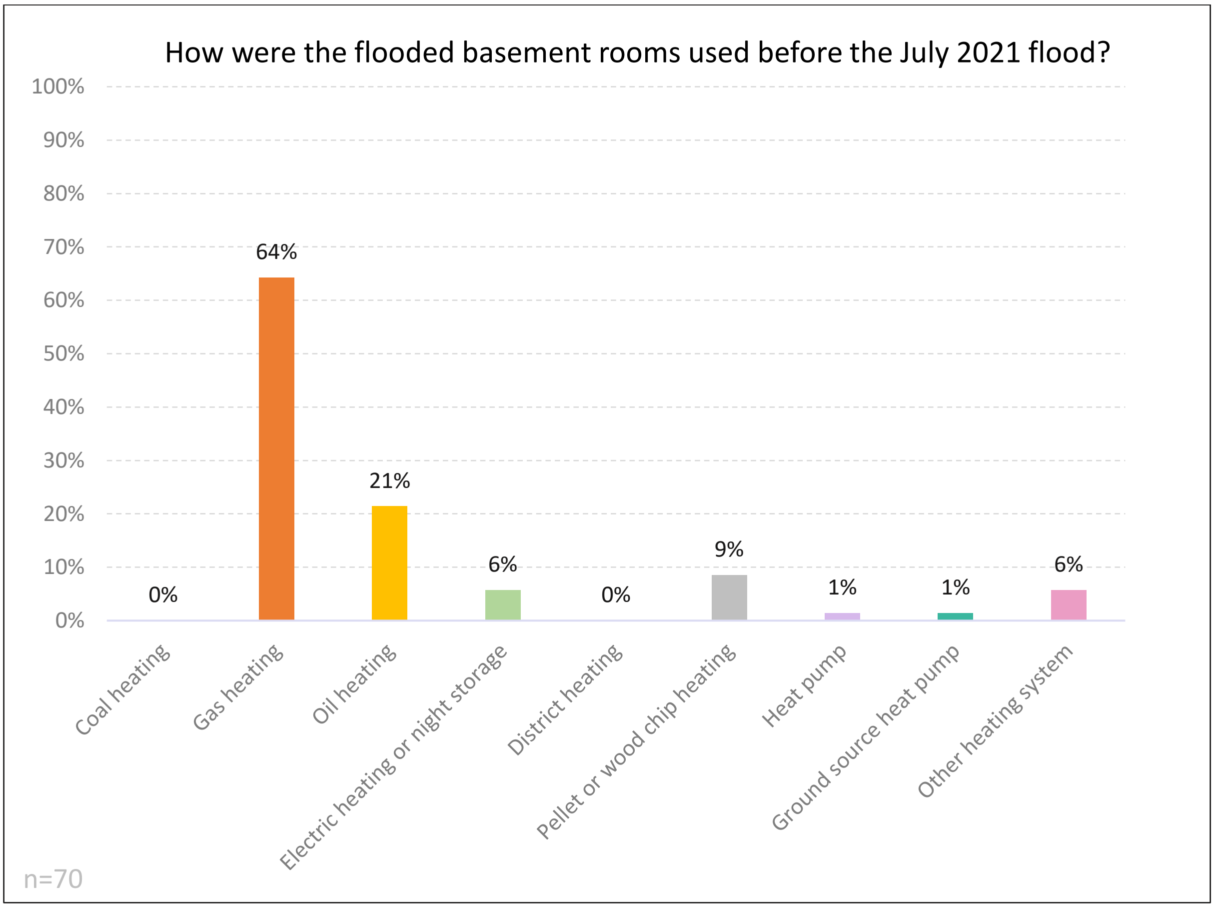



*Figure 188: Percentages of the heating systems of the participants, Germany (questionnaire part 2 residential, question 35).*

*Table 19 : Other heating system than mentioned in question 35, Germany (questionnaire part 2 residential, question 36).*

| Abundance | Other heating systems |
|---|---|
| 1 | Oil stoves |
| 1 | LPG |
| 2 | Solar heat |

*Table 20: Other place for the heating system than mentioned in question 37, Germany (questionnaire part 2 residential, question 38).*

| Abundance | Other place for heating system |
|---|---|
| 1 | In every room |
| 1 | No central heating system |

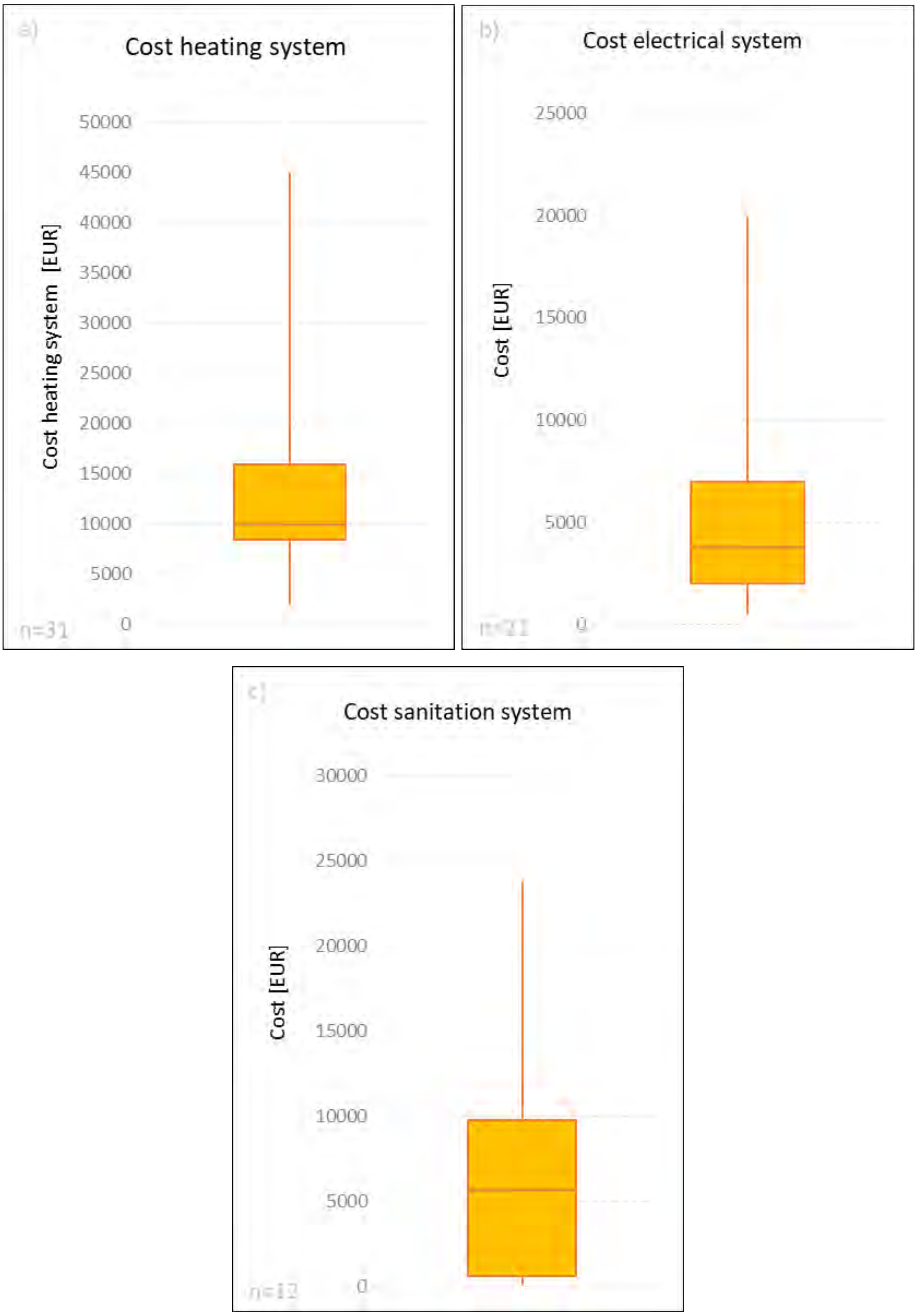



*Figure 189: Box plot of the total cost for repairing the a) heating system, b) electrical system and c) plumbing and sanitation system, Germany (questionnaire part 2 residential, question 39-41).*

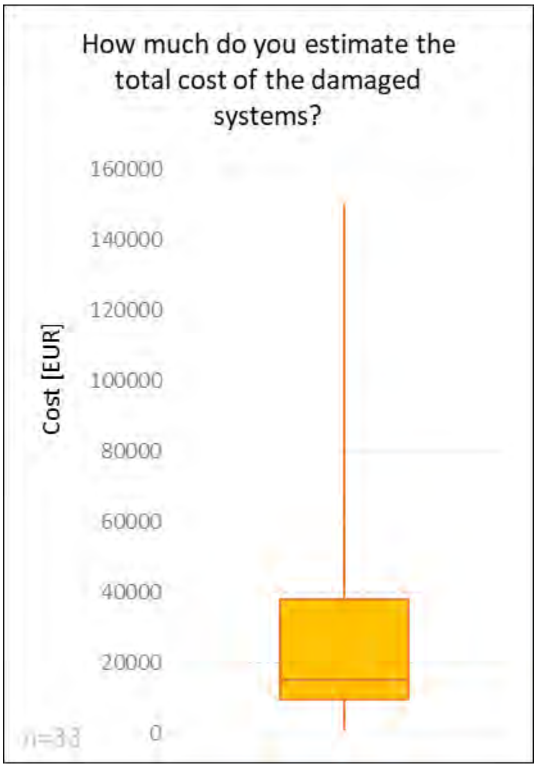



*Figure 190: Box plot of the total cost for repairing the damages systems, Germany (questionnaire part 2 residential, question 42).*

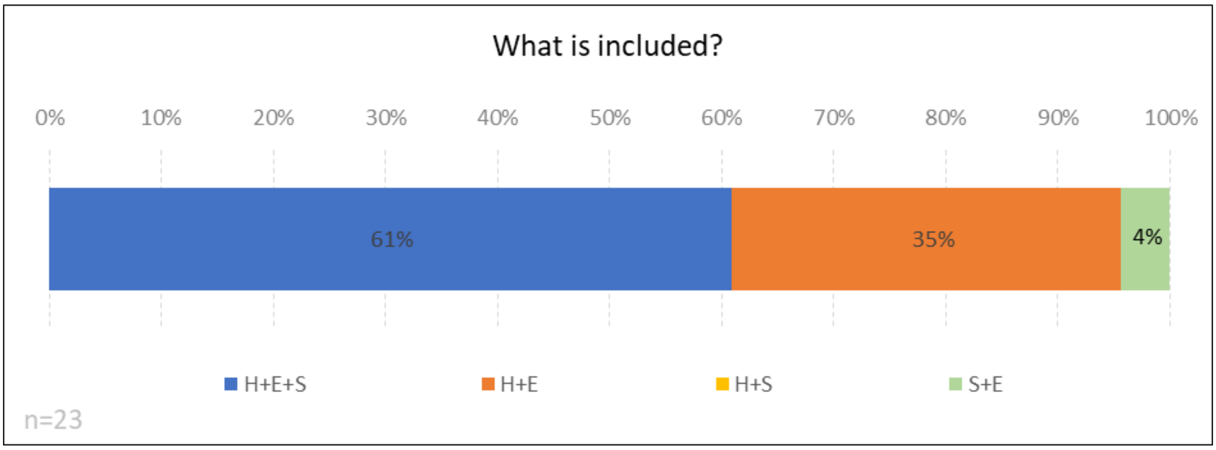



*Figure 191: Percentage of what is included in the total cost of question 42 (H: heating system, E: electrical system, S: sanitation and plumbing system), Germany (questionnaire part 2, question 43).*

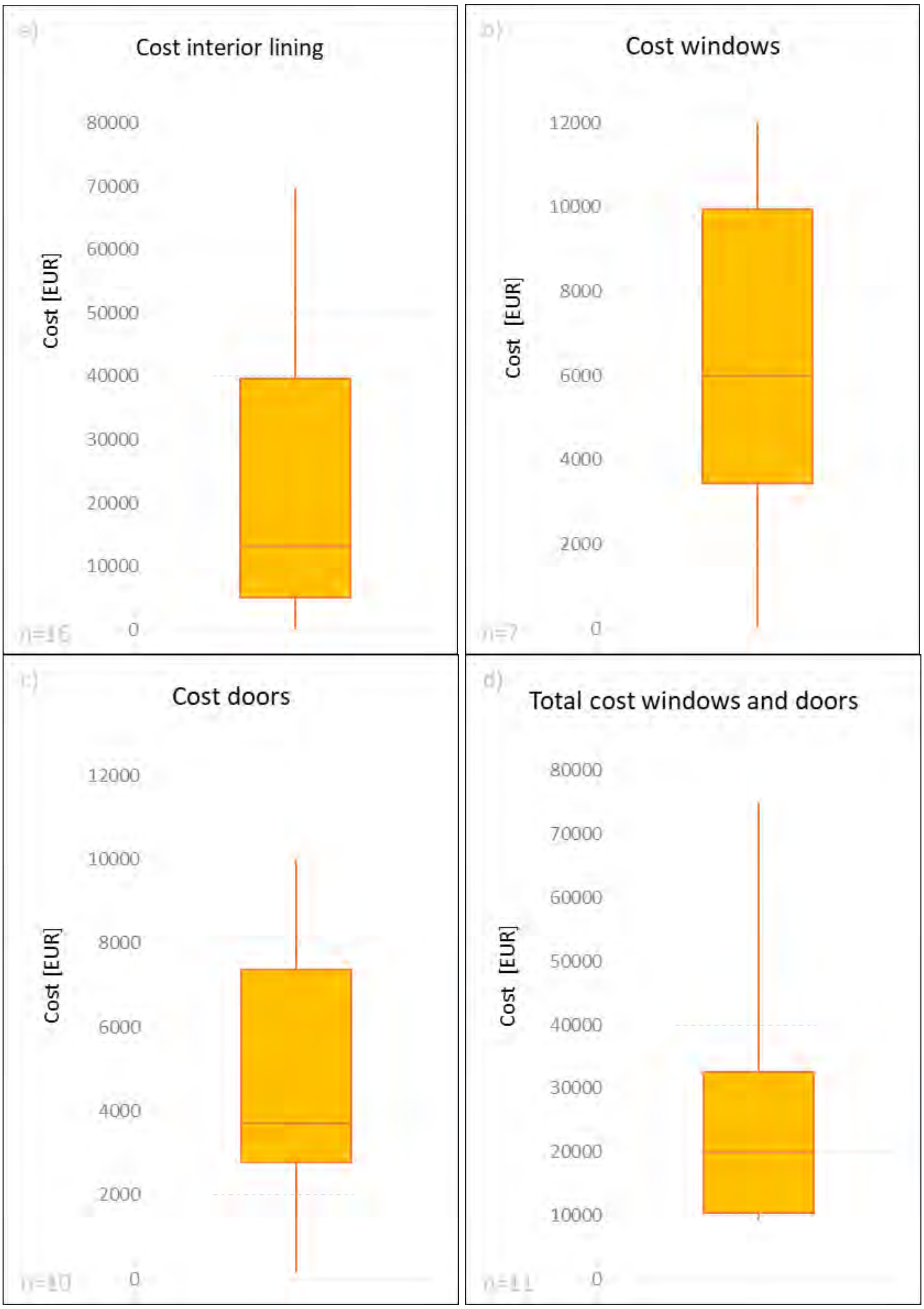



*Figure 192: Box plot approximate damage cost a) to replacement of the interior lining, b) of damage to windows, c) of damage to doors, d) of windows and doors, Germany (questionnaire part 2 residential, question 45-48).*

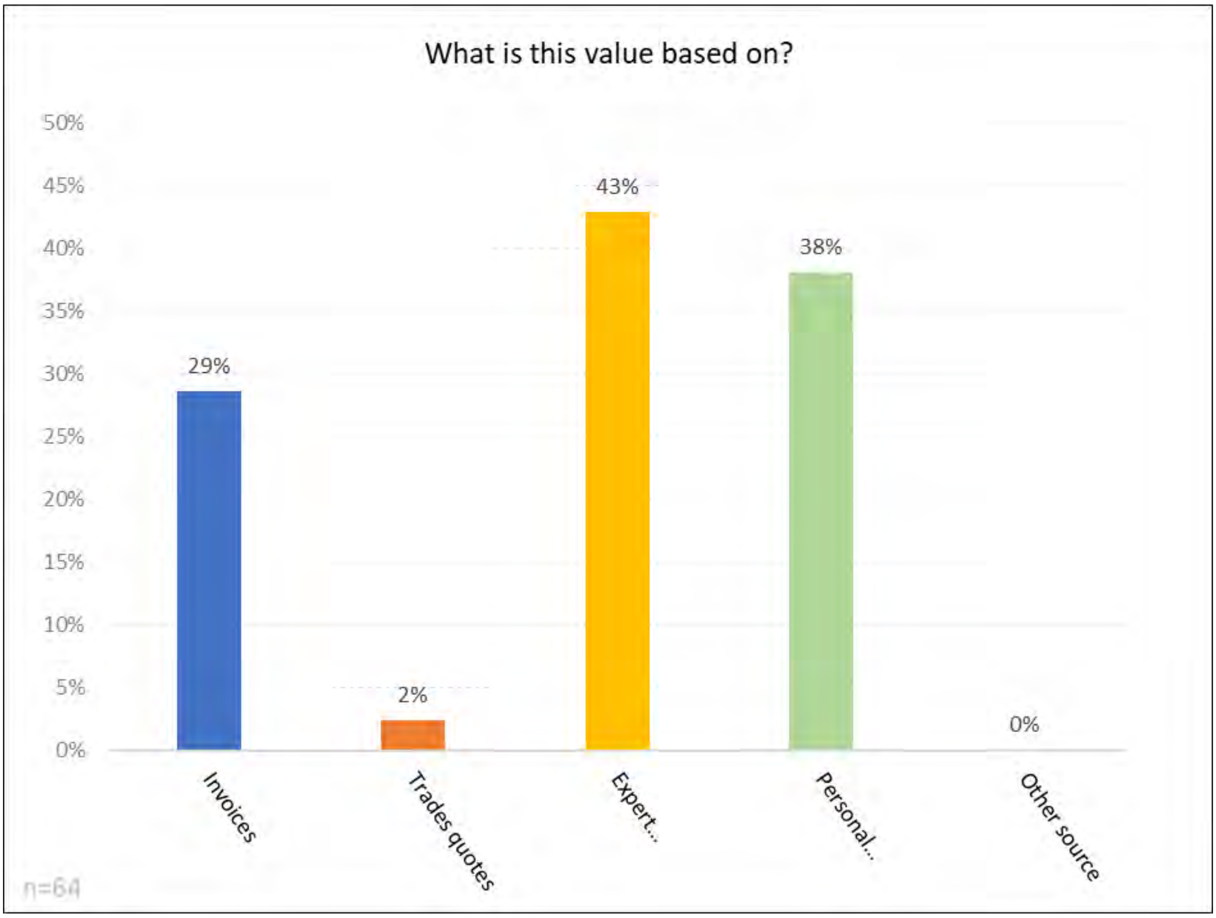



*Figure 193: On which the value of the total amount of damage is based, Germany (questionnaire part 2 residential, question 51)*

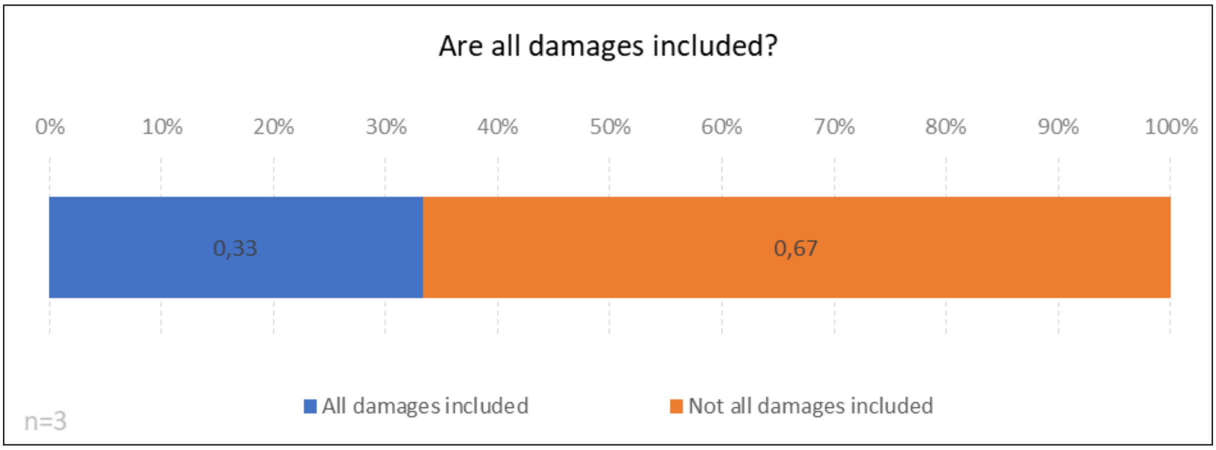



*Figure 194: Percentage of cost that included all damages, Germany (questionnaire part 2 residential, question 53)*

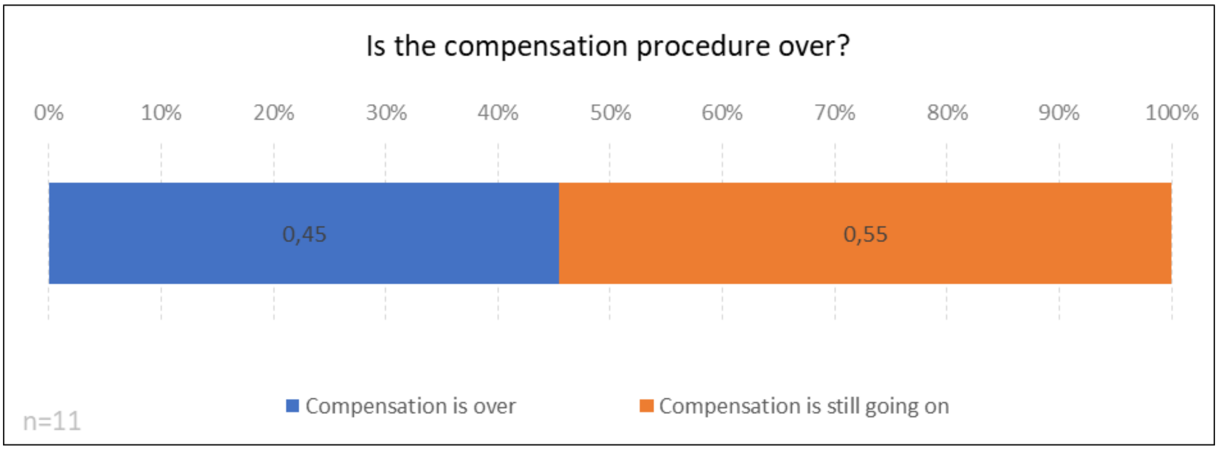



*Figure 195: percentage if the compensation procedure is over, Germany (questionnaire part 2 residential, question 54)*

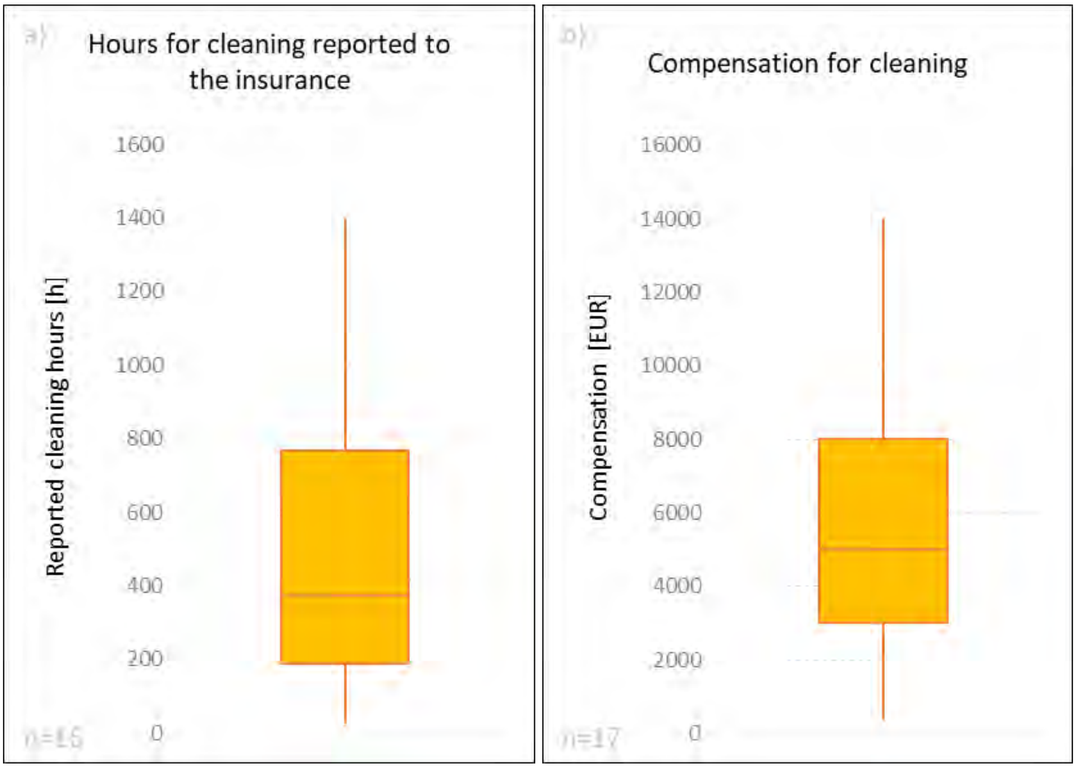



*Figure 196: Box plot cleaning the building, a) reported cleaning hours to the insurance, b) compensation for cleaning from insurance, Germany (questionnaire part 2 residential, question 55-56)*

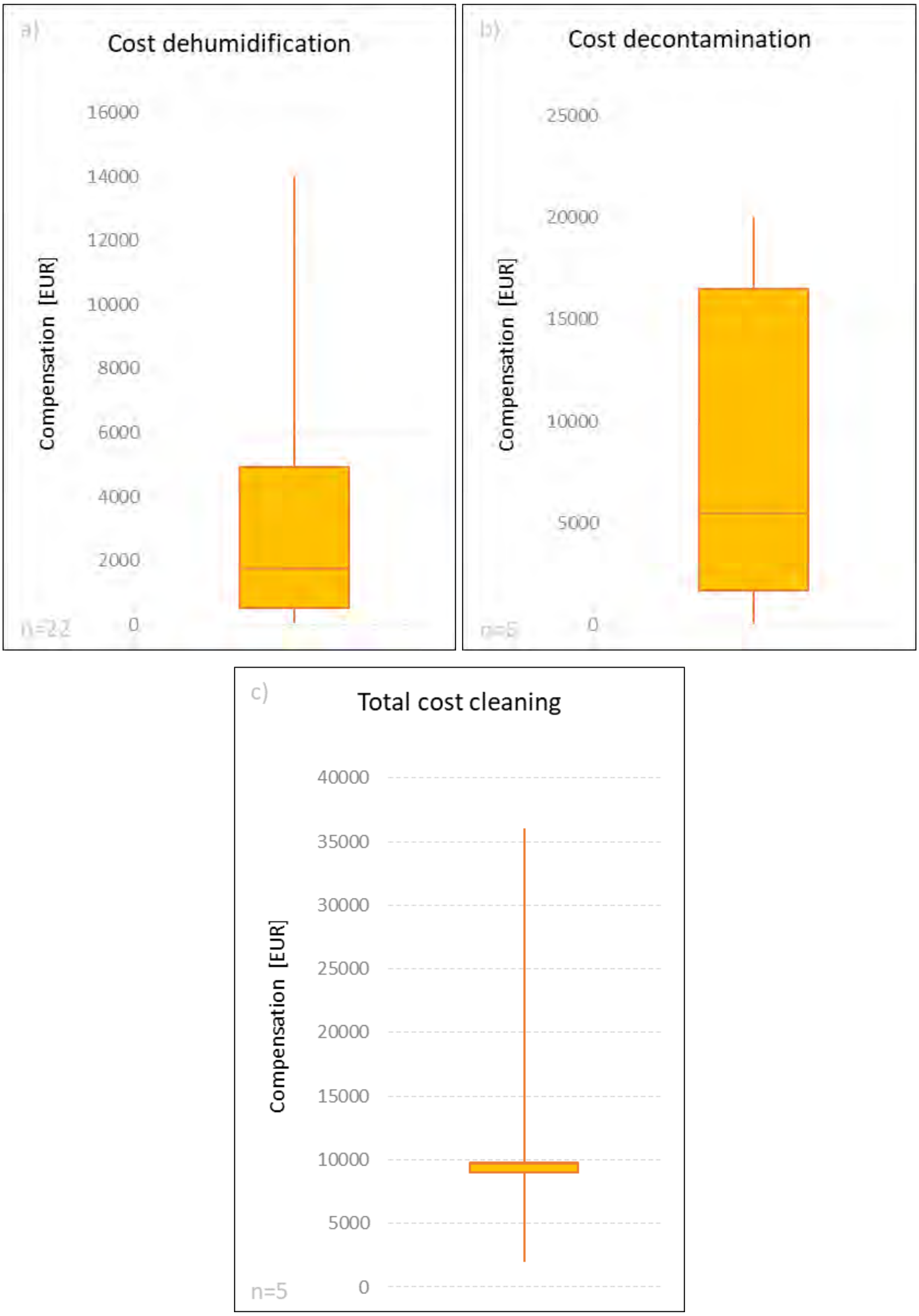



*Figure 197: Box plot representing cleaning costs, a) cost of dehumidification, b) costs of decontamination, c) total coasts to the cleaning of the building, Germany (questionnaire part 2 residential, question 57-59)*

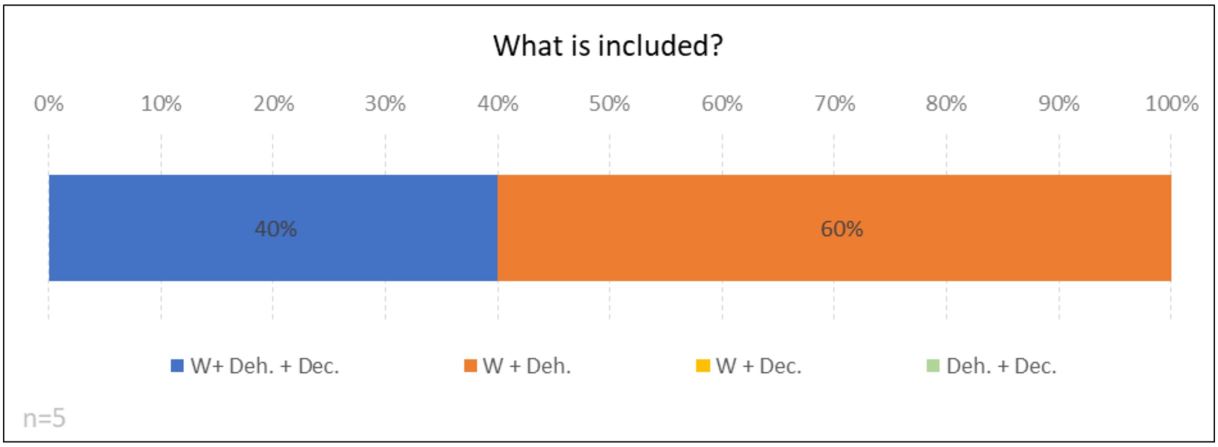



*Figure 198: Percentages of what is included in the total cleaning cost, Germany, W : Waste disposal, Deh. : Dehumidification, Dec. : Decontamination (questionnaire part 2 residential, question 60).*

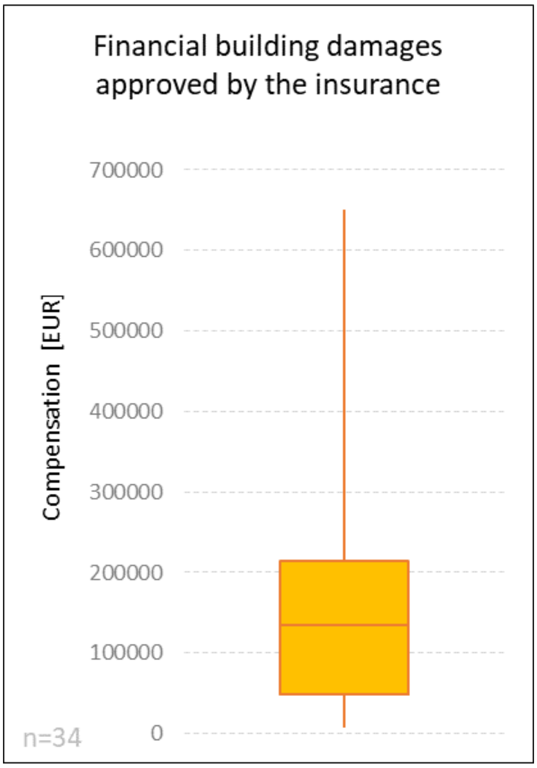



*Figure 199: Box plot of the approved amount of damage to or in the building by the insurance company, Germany (questionnaire part 2 residential, question 61).*

*Table 21: Other types of financial help than mentioned in question 66, Germany (questionnaire part 2 residential, question 67).*

| Abundance | Other types of financial help |
|---|---|
| 1 | Selling the house: 75,000€ |
| 2 | Interest-free bank loan |

*Table 22: Other reasons for not receiving financial help than mentioned in question 68, Germany (questionnaire part 2 residential, question 69).*

| Abundance | Other reasons for not receiving financial help |
|---|---|
| 1 | Did not apply for it yet |

*Table 23: Answers to the question, which needs participants still had at the time of the interview, that had not yet been addressed, Germany (questionnaire part 2 residential, question 74).*

| Number | Which needs do you still have that have not yet been addressed? |
|---|---|
| 1 | Still no branch of bank, post office, and grocery shop |
| 2 | Embarkment is nearer to the house now, need to be fixed by the waterboard but they don't want to because they want a natural river, house is in great danger at the next flood; rain water retention basin in Roetgen was planned for long time but not built because officials didn't see the need; address is a little bit isolated and warnings of the fire brigade didn't reach them. |
| 3 | Warning is not important, but climate change should be considered: take precautions, flood prevention in the form of flood retention basins, etc., operate dam; flexible, should also be operated against the rules (e.g., 30%) |
| 4 | She has been pretty much ignored, people did not ask her if she needed help (e.g., fire department for pumping out water from basement), only people living near to the water were helped |
| 5 | Waited longer for the generators |
| 6 | Reconstruction aid was promised by politicians to be simple, direct and unbureaucratic, but it was super complicated instead |
| 7 | Just wants everything to be finished, otherwise everything is fine |
| 8 | Embankment wall not as before |
| 9 | Applications from the federal government extremely complicated, although it was said it should be simple; that mayor not only says that everything will be fine, but that actually someone comes by; that the water board comes as promised and looks at the wall at the creek |
| 10 | Warning system that was installed after flood relies on electricity -> electricity was not available during flood; better is radio; no compensation received yet |
| 11 | Dry weather: clean streams properly, it is officially done, but there is still a lot of garbage in the stream; stream still doesn't have the depth as before; after 1.5 years a complete car, bicycles, barrels, washing machine, shopping cart were taken out of the stream again |
| 12 | Financially well cared for, emotionally institutionalized; good: citizen's office garden tool rental, etc. from city |
| 13 | Social and psychological care for seniors, cleaning up the banks of the Inde |
| 14 | Insurance would be good if processing was faster; architect/construction manager who coordinates and controls everything; better craftsmen who do not make a profit from the damage; someone who helps you with insurance, etc.; if someone has estimated damage initially and clarified with insurance company |
| 15 | Bay window needs repair |
| 16 | Garden |
| 17 | Handicap incapacity |
| 18 | Too complicated to apply for some aid funds |
| 19 | See field report |
| 20 | See field report |

| | |
|---|---|
| 21 | People from waterboard and operators of the Dreilägerbach dam should be made accountable |
| 22 | Rebuild the courtyard |
| 23 | More an nearer gauges need to be installed; sirens should be functional; material should be removed from the stream bed |
| 24 | Flood retention basin(s) should be built |
| 25 | Can't hear about it anymore, because tired of it |
| 26 | Approval of applications so financial situation allows to pay the manual workers |
| 27 | Wishes for more participation of the church |
| 28 | Contact persons for more transparency in bureaucracy |
| 29 | Early warning system must be improved, change in the regulation of the dam. |
| 30 | Improvement of flood protection in the future, easier handling & communication with water association, Stream should be cleaned up |
| 31 | Private bridge opposite not yet repaired |
| 32 | Next door had a better support by officials and municipality; maybe ask the people what they need, so municipality knows where to help |
| 33 | Fix wall by the stream, mental and physical health |

*Table 24: Answers to the question, what could have been done better in term of information/support from government/own capabilities, Germany (questionnaire part 2 residential, question 75).*

| Number | What could have been done better in terms of information/support from government/ own capabilities? |
|---|---|
| 1 | Adress is a little bit isolated, and warnings of the fire brigade didn't reach them. |
| 2 | In the radio was announced that the people were safe from the flood -> was wrong!, insurance was unprepared, uninformed, pedantic ad wanted to cap the total sum; you needed a verification from you bank to get the money from the insurance |
| 3 | Also drive in side streets |
| 4 | Better and earlier warning, mobile network after flood would have helped |
| 5 | Federal government application for reconstruction fees complicated. |
| 6 | Entrepreneurs (craftsmen) have screwed the people |
| 7 | Drinking water dam must also be used for flood control; drinking water had greenish yellow color; could not drink; could not rely on electricity; zero disaster control -> warn in time, believe warnings of meteorologists |
| 8 | Financially well taken care of; institutionalize emotional/psychological care; what was good: citizen's office garden tool rental etc. from the city |
| 9 | Poor communication, not taken seriously by fire department |
| 10 | Retention basins & areas on the Hasselbach, everyone only talks about the Vichtbach; there would have been enough space for retention above Zweifall; forester has offered to create areas. |
| 11 | Warning system |
| 12 | One lives with fear |
| 13 | Information was disseminated via internet although there was no electricity/internet connection |
| 14 | Improve early warning, Sirens |
| 15 | Knocking on doors |
| 16 | Specified flood protection is not enforced |
| 17 | Too many applications, lack of communication between dams |
| 18 | Should warn earlier |
| 19 | Sirens, Fire department announcement |

| | |
|---|---|
| 20 | Warning |
| 21 | Early warning system: sirens, text messaging |
| 22 | Too complicated to apply for some aid funds |
| 23 | See field report |
| 24 | See field report |
| 25 | Help after the flood was very good |
| 26 | Donations reach people very late |
| 27 | No, everything was fine |
| 28 | Didn't get a warning, would had need a warning; THW was completely overchallenged and not well organized |
| 29 | Help, funds & solidarity was great; information/warning was a disaster |
| 30 | There should have been a warning; official should have been more honest an informative after the event |
| 31 | Warning, should inform the people about what is going to be changed regarding flood protection, Fire department was really dedicated |
| 32 | Early enough warning; sandbags in enough abundance |
| 33 | The day after the flood, it took until late in the afternoon for someone to come forward to help. Later it was better. Help came from all sides. On the first day, people felt abandoned. |
| 34 | Church should have helped more |
| 35 | Sirens |
| 36 | Nothing |
| 37 | Disaster management must be improved, warnings must be operated better, rescue services must be better prepared for disasters, communication between official bodies and the population must take place |
| 38 | Applications for reconstruction aid too complicated; wanted proofs afterwards that were never mentioned before; took forever |
| 39 | No psychological help received despite request to the Malteser |
| 40 | Went quite well; communication about what measures are planned |
| 41 | Siren flood warning with individual level |
| 42 | Faster receipt of information: Fire department announcements, sirens |
| 43 | Nature conservation is put before flood protection |
| 44 | Loudspeaker announcements |
| 45 | Early warning system needs to be improved; change in regulation of the dam |
| 46 | Warning |
| 47 | Private bridge is still not repaired |
| 48 | Communication/education of city, state, region should run better; concrete indication how high the water rises; warning, follow-up monitoring, picture for preventive flooding! |
| 49 | At the beginning there was a lot of help; help from the state was super complicated, to get financial help from the officials was not easy, because it was not all online |
| 50 | Communication before the flood arrives |
| 51 | Applications should be approved. The amount should be financially enough that craftsmen are paid |

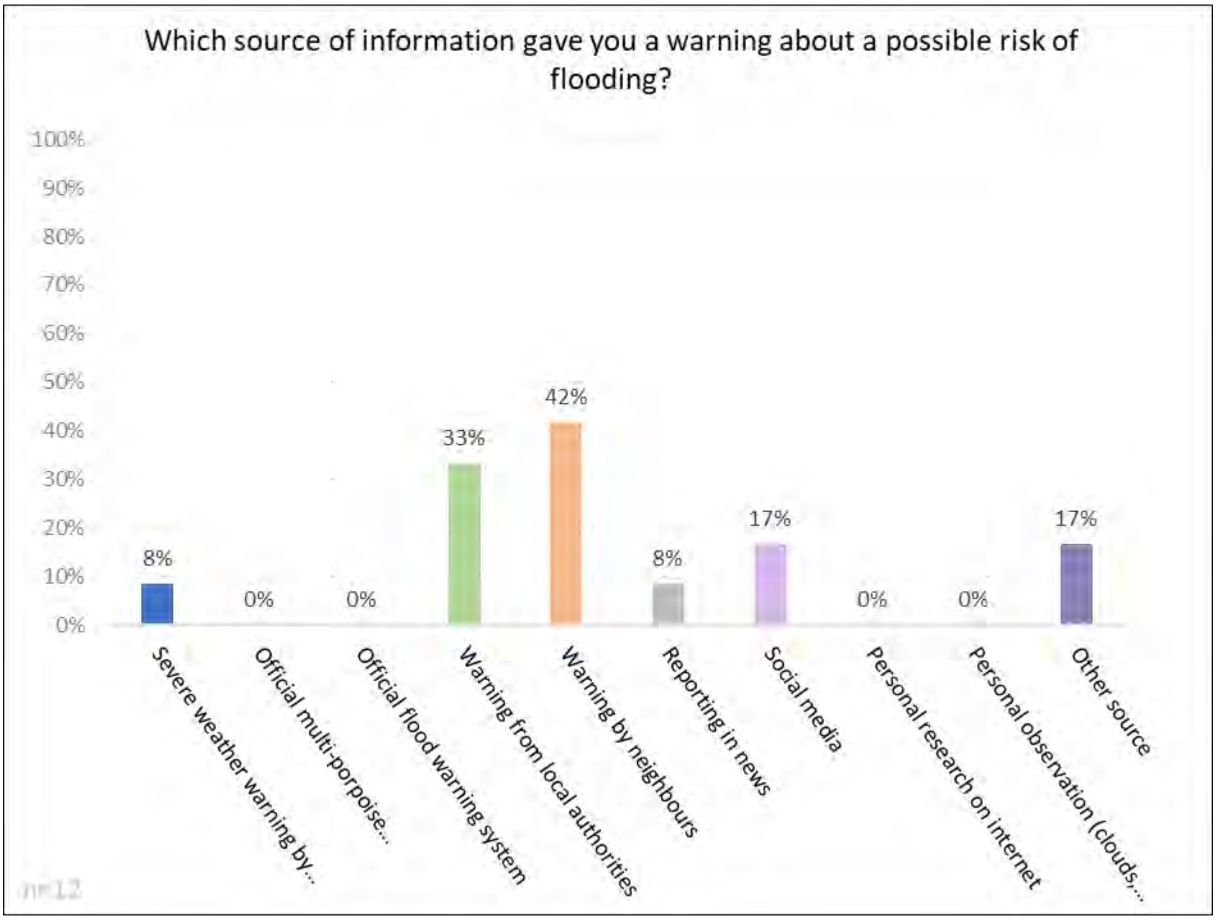



*Figure 200: Percentages of information source which gave people a warning about a possible risk of flooding, Germany (questionnaire part 2 residential, question 77).*

*Table 25: Other warning sources than mentioned in question 77, Germany (questionnaire part 2 residential, question 78).*

| **Abundance** | **Other warning sources** |
|---|---|
| 1 | Shouts, screams from outside, colliding cars. |
| 1 | Called the fire brigade by himself and asked for information. |

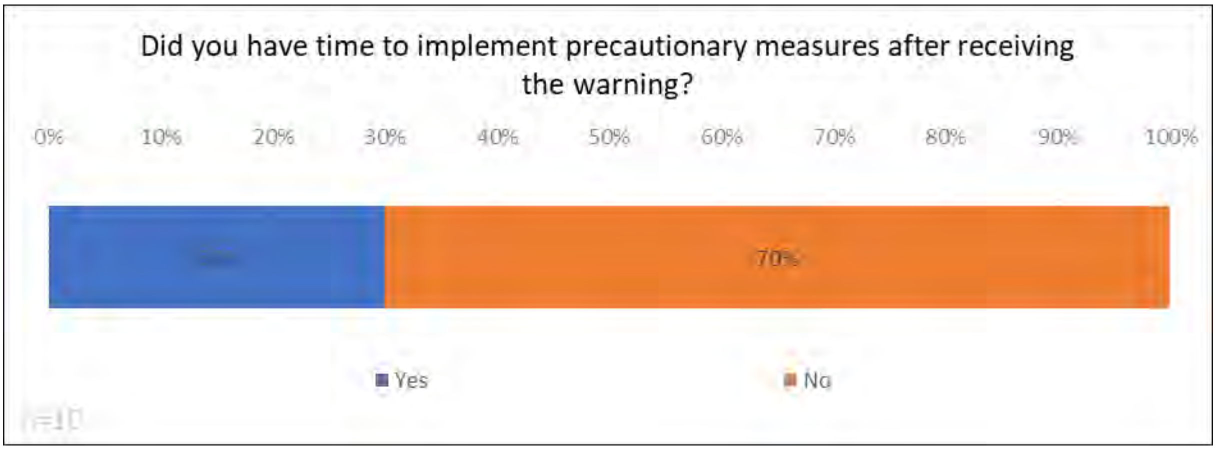



*Figure 201: Percentage of having time to implement precautionary measures after the warning, Germany (questionnaire part 2 residential, question 80).*

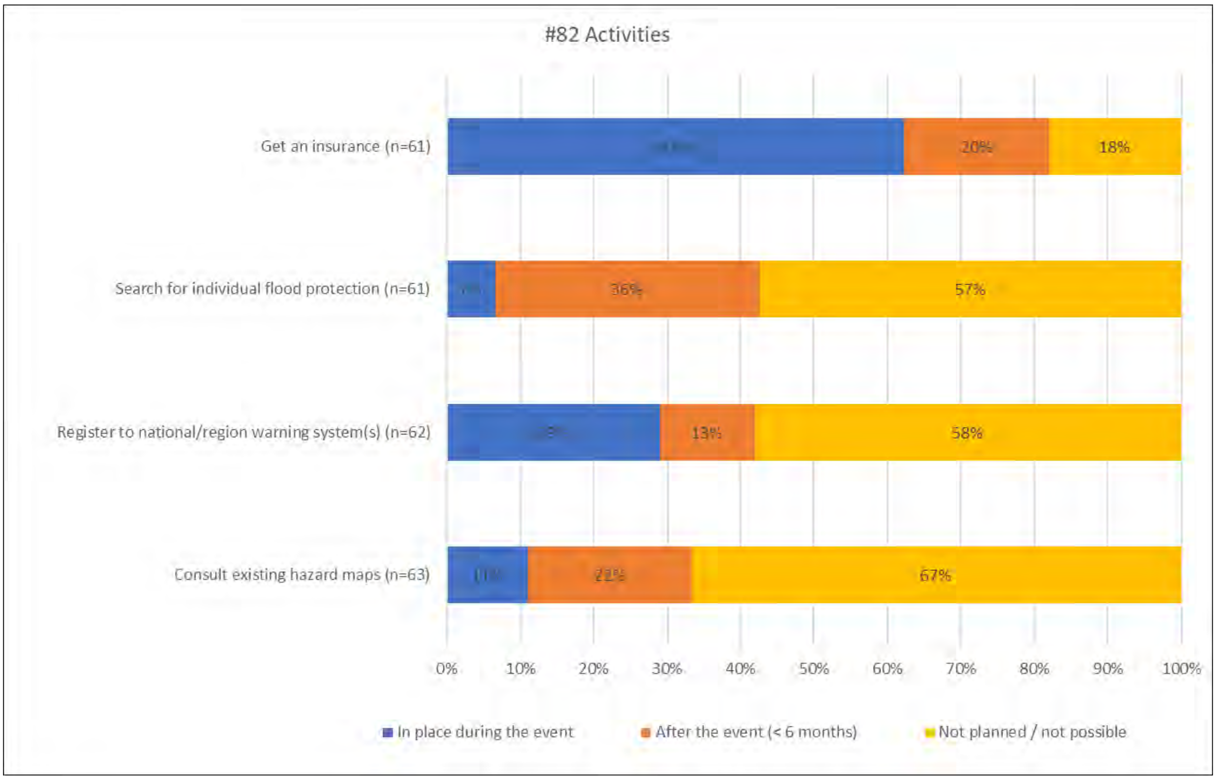
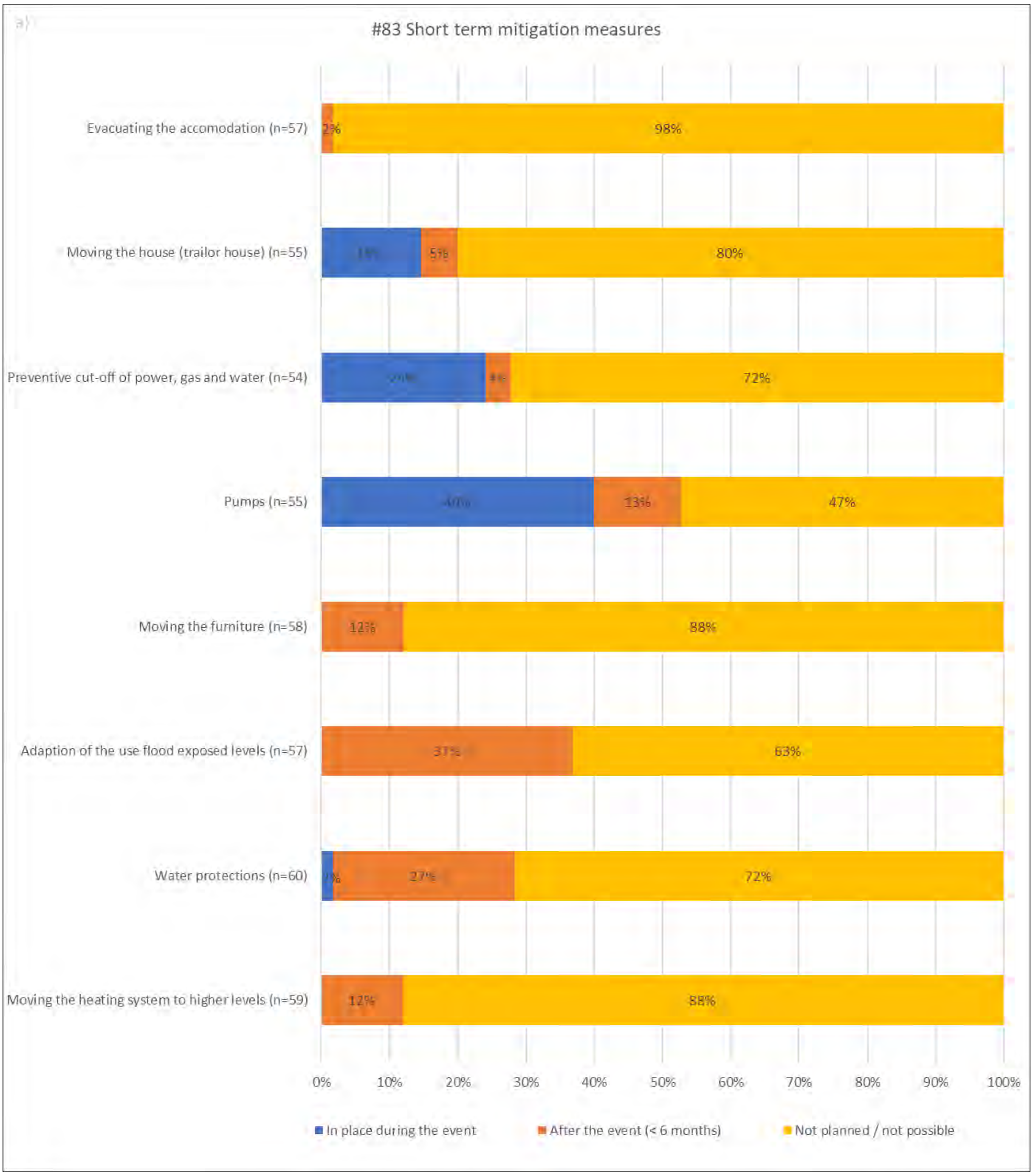



*Figure 202: Percentages of activities to be better informed of what to do in case of flood, Germany (questionnaire part 2 residential, question 82).*



a)
#83 Short term mitigation measures
Evacuating the accomodation (n=57)
2%
98%
Moving the house (trailor house) (n=55)
5%
80%
Preventive cut-off of power, gas and water (n=54)
4%
72%
Pumps (n=55)
13%
47%
Moving the furniture (n=58)
12%
88%
Adaption of the use flood exposed levels (n=57)
37%
63%
Water protections (n=60)
27%
72%
Moving the heating system to higher levels (n=59)
12%
88%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
In place during the event
After the event (< 6 months)
Not planned / not possible

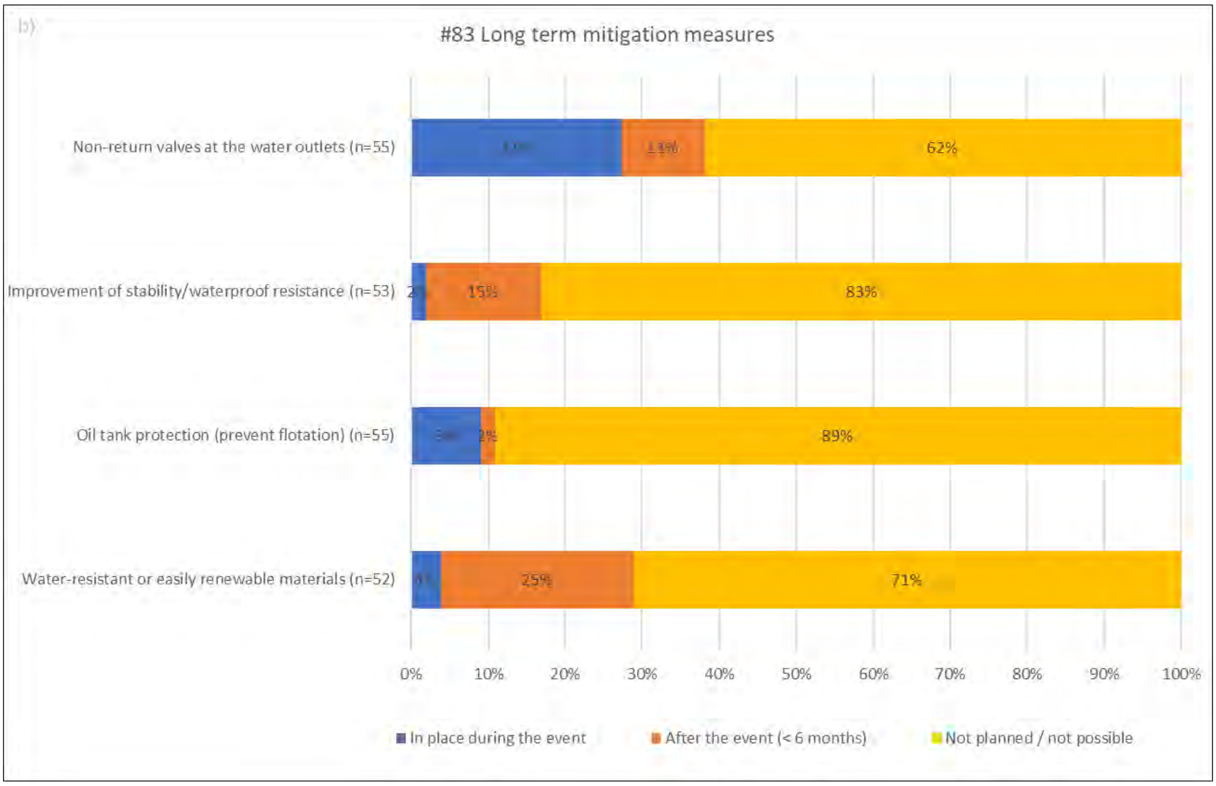



*Figure 203: Percentage of a) short term mitigation, b) long term mitigation measures, Germany (questionnaire part 2 residential, question 83).*

# Netherlands

## Survey Statistics

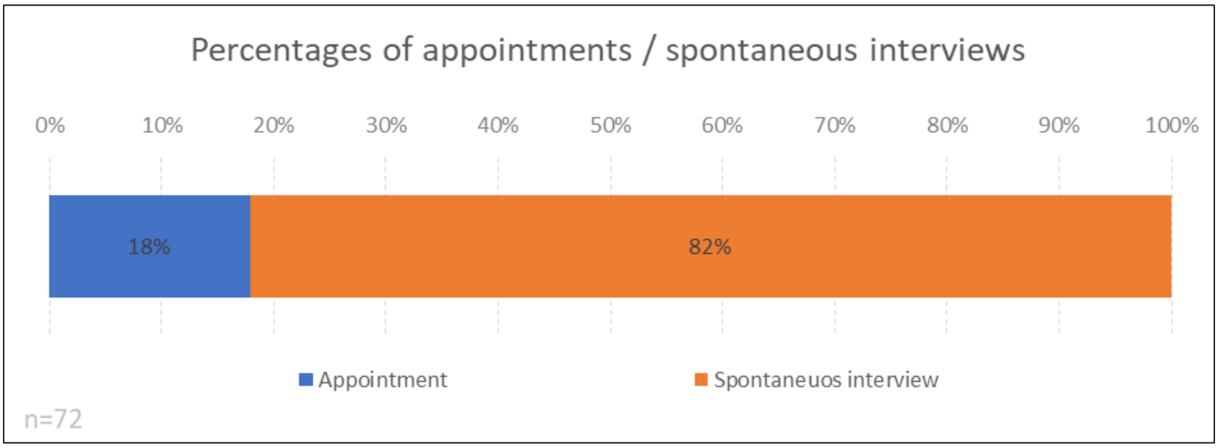



*Figure 204: Percentages of appointments/spontaneous interviews, Netherlands.*

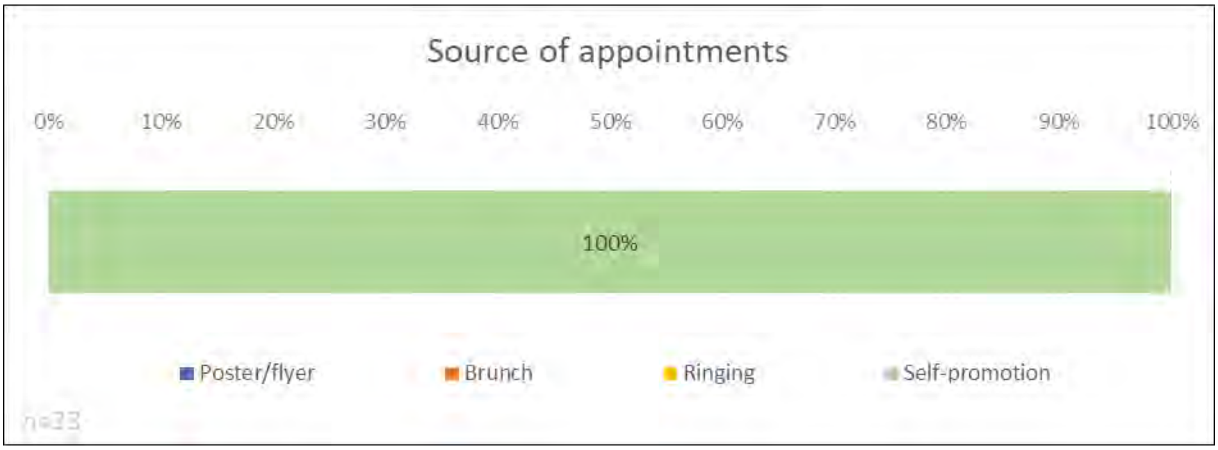



*Figure 205: Source of appointments, Netherlands.*

## Part 1

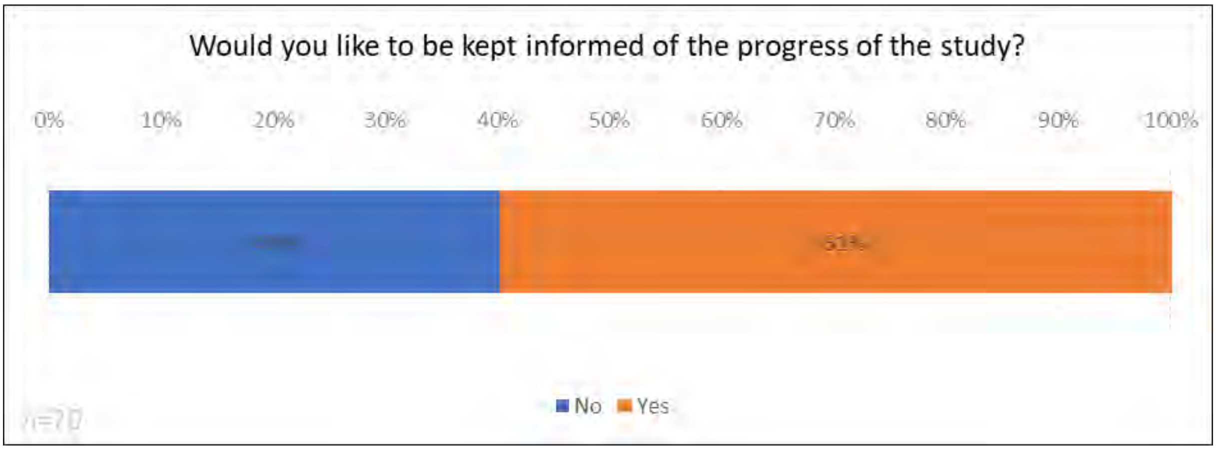



*Figure 206: Percentages of participants who want to be kept informed of the progress of the study, Netherlands (questionnaire part 1, question 14).*

## Part 2 residential

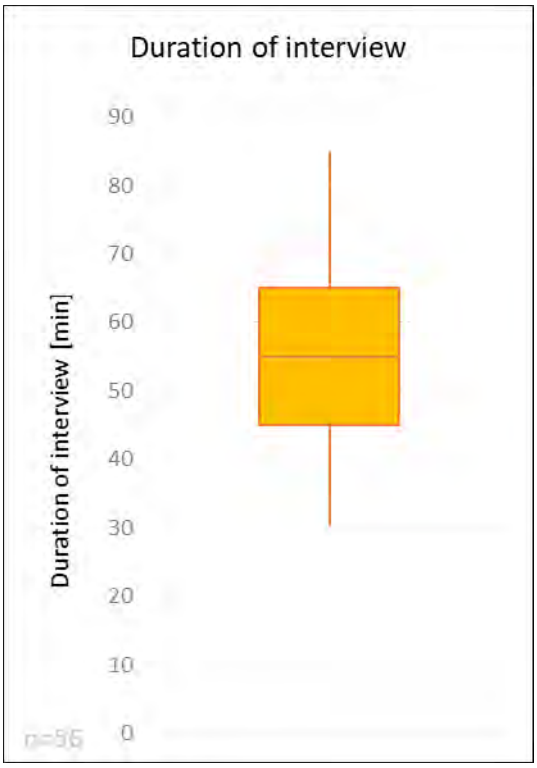



*Figure 207: Box plot of the interview durations, Netherlands (questionnaire part 2 residential, questions 1 & 87).*

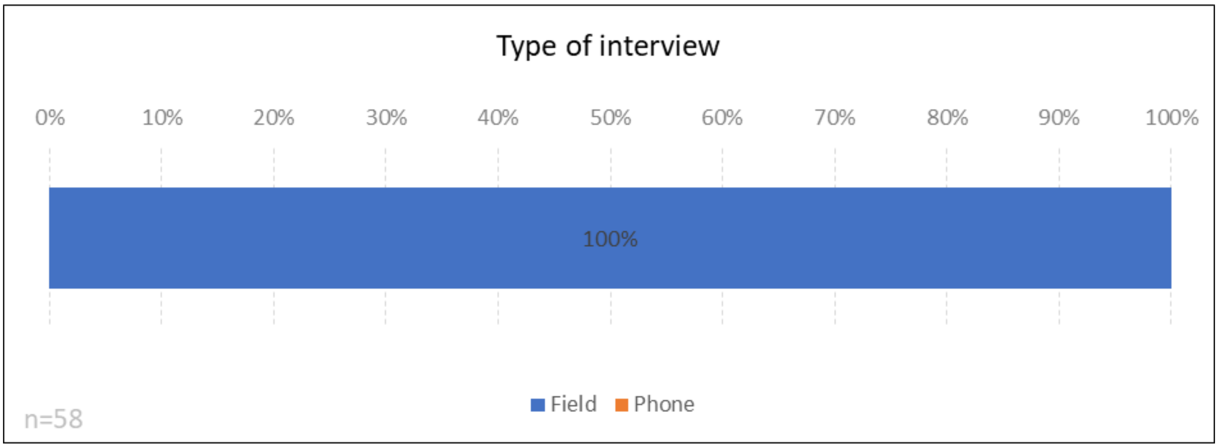



*Figure 208 : Type of interview, Netherlands (questionnaire part 2 residential, question 2).*

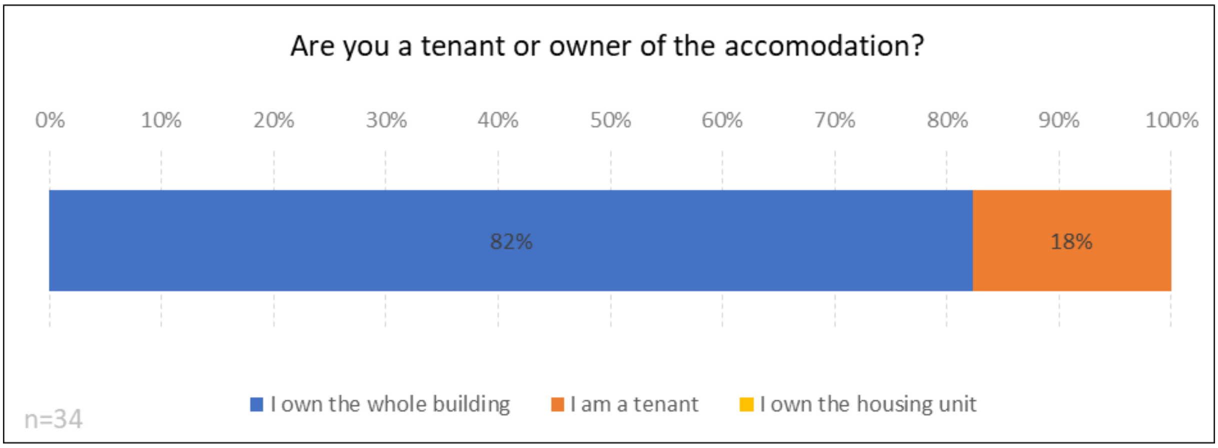



*Figure 209: Percentages of the participants who are owners or tenants of their home, Netherlands (questionnaire part 2 residential, question 4).*

*Table 26: List of other recorded causes of flooding, Netherlands (questionnaire part 2 residential, question 6).*

| Abundance | Other causes of flooding |
|---|---|
| 1 | Low garden as with many |
| 1 | Water level rise against the fish storage |

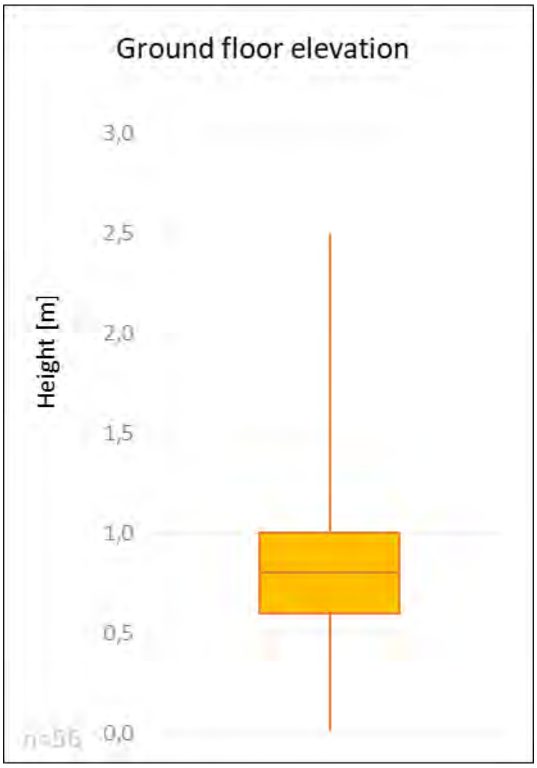
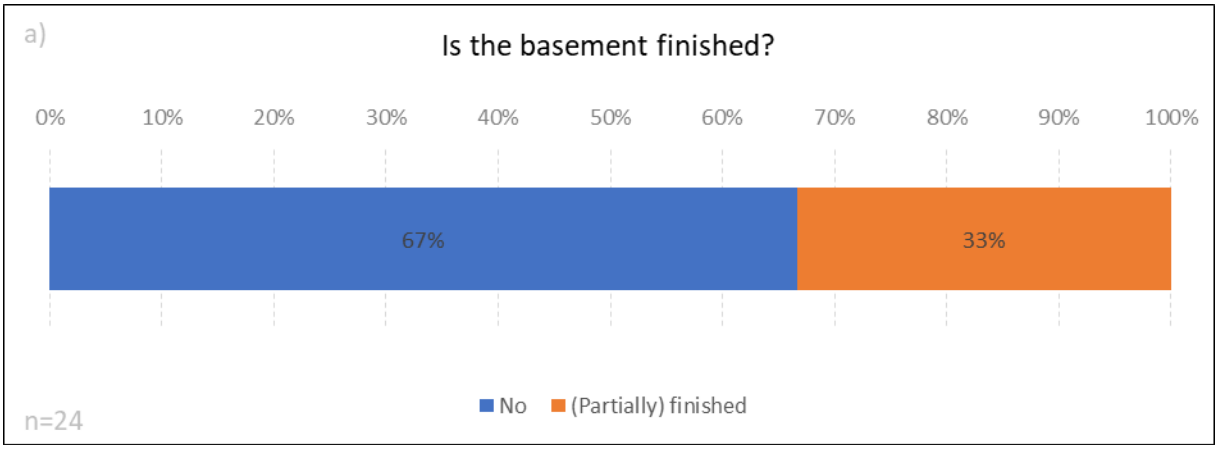



*Figure 210: Box plot of the elevation between street level and the ground floor of the buildings, Netherlands (questionnaire part 2 residential, question 8).*



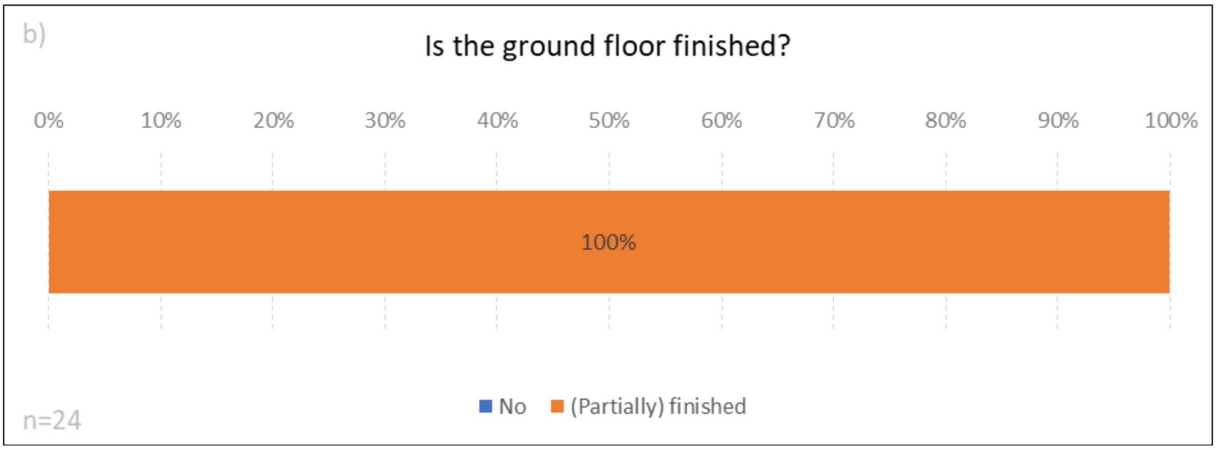




*Figure 211: Percentage of finished levels in the buildings of the participants, a) basement and b) ground floor, Netherlands (questionnaire part 2 residential, question 10).*

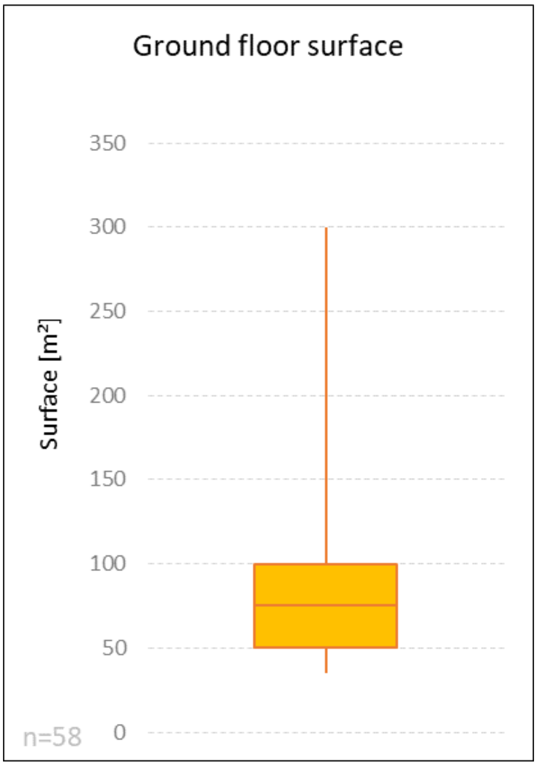



*Figure 212: Box plot of the ground floor surface of the buildings, Netherlands (questionnaire part 2 residential, question 15).*

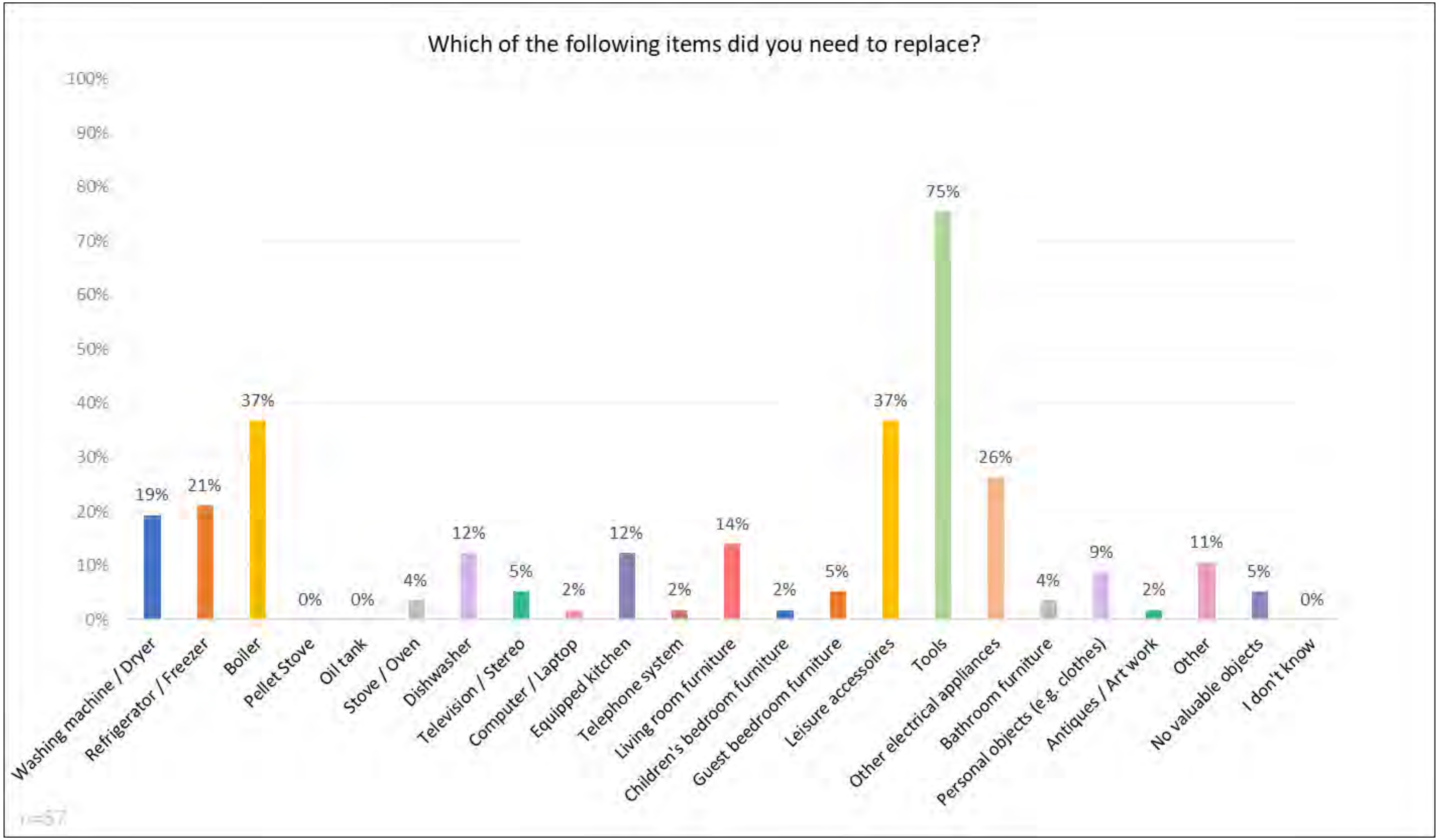
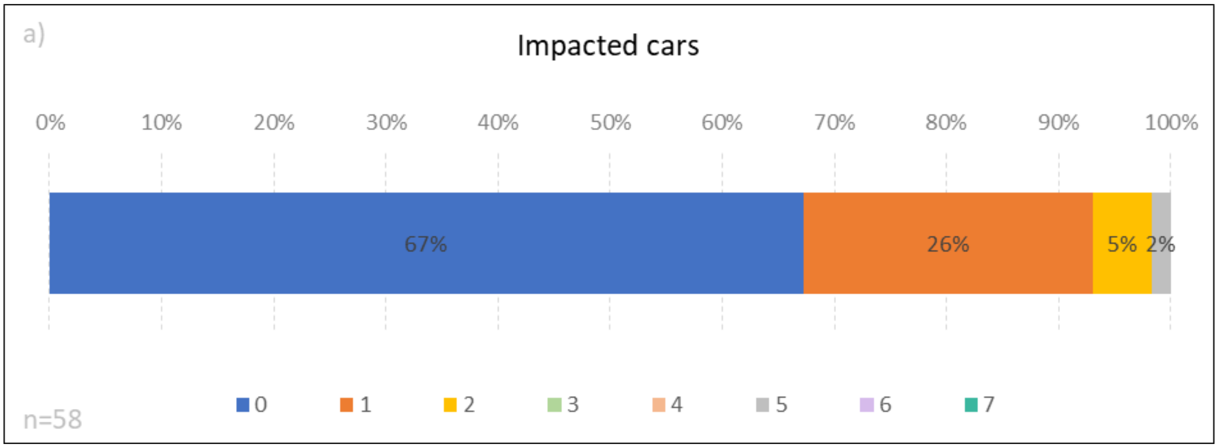



*Figure 213: Percentages of the household items, the participants did need to replace, Netherlands (questionnaire part 2 residential, question 16).*

*Table 27:Other voluminous/expensive items than available in question 16, Netherlands (questionnaire part 2 residential, question 17).*

| Abundance | Other voluminous/expensive items |
|---|---|
| 1 | Photos |
| 1 | Baby goods |
| 1 | Building material |
| 1 | Landscaping material |
| 1 | Weapons |
| 1 | Dog Kennel |
| 1 | Old wines |
| 1 | Golf gear |
| 1 | Inverter solar panels |
| 1 | Jacuzzi |
| 1 | Window frames |
| 1 | Garage door |
| 1 | Front door |
| 2 | Floor |
| 1 | Birds plus extras |
| 1 | Land mower |
| 1 | Food supply |
| 1 | Trailer |
| 1 | Care supplies |
| 1 | Electric well pump |
| 1 | Water pumps |



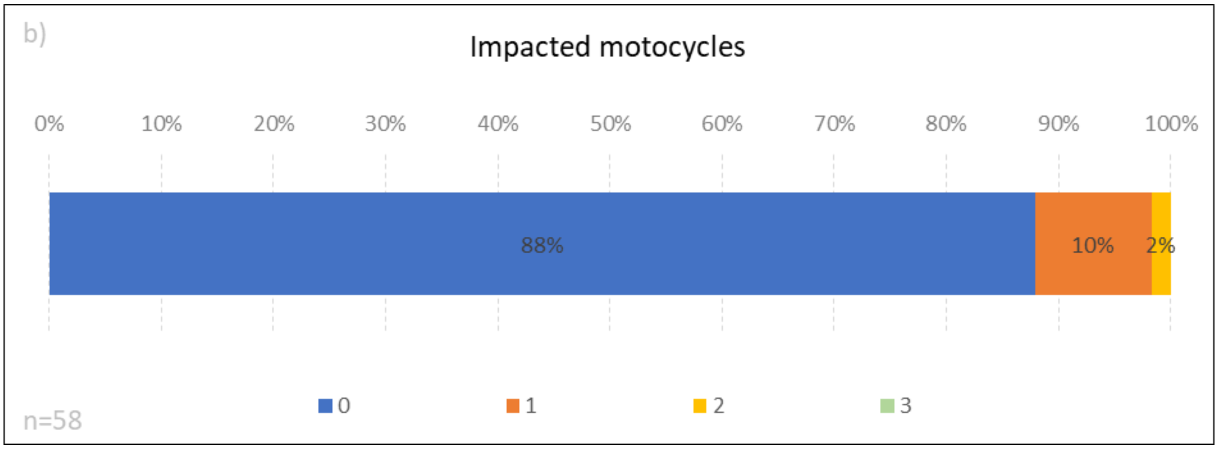




*Figure 214: Percentages of participants who had a) one/several car(s) or b) one/several motorcycles impacted by the flood, Netherlands (questionnaire part 2 residential, question 18).*

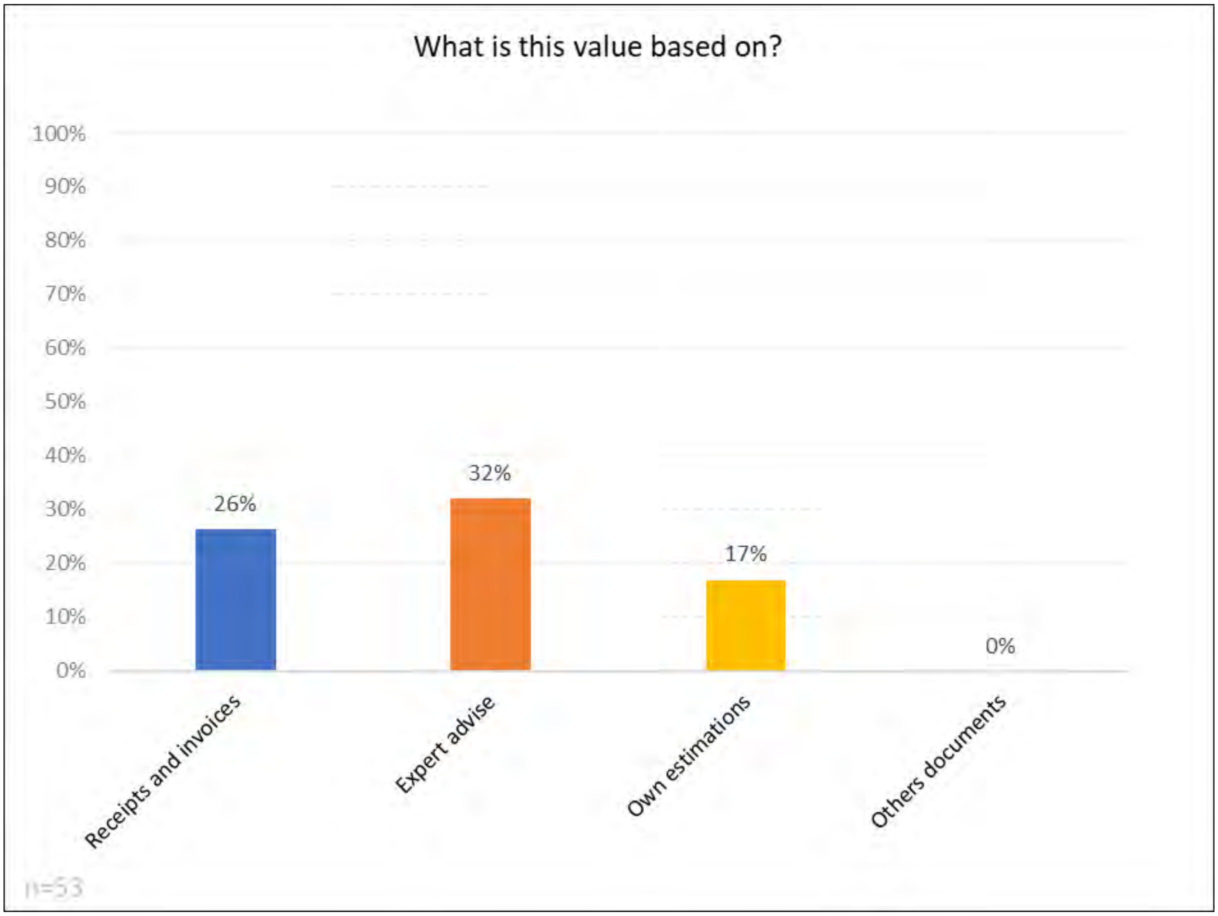



*Figure 215: Percentages of the base of the values from question 19, Netherlands (questionnaire part 2 residential, question 20).*

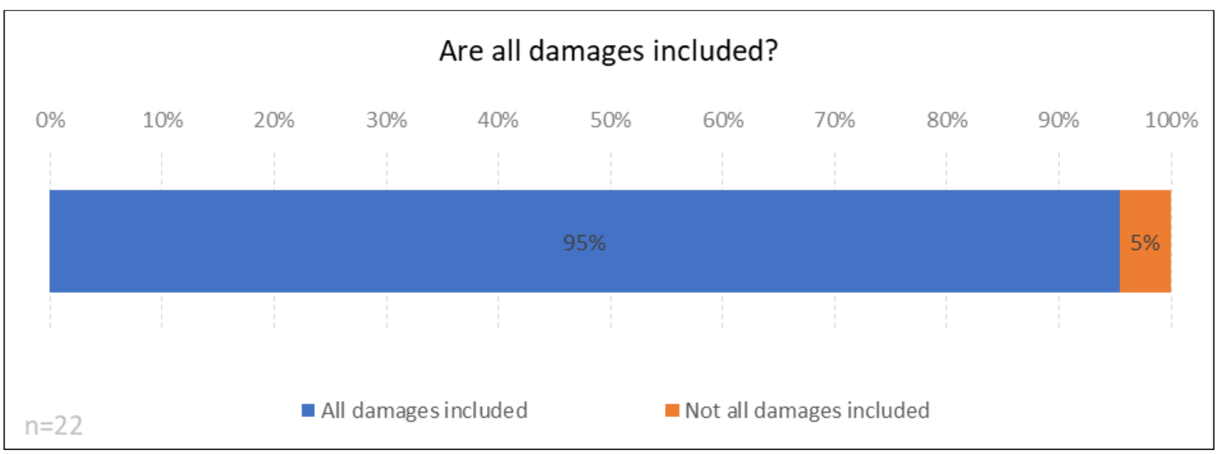



*Figure 216 : Percentage of cases in which all damages are included in question 19, Germany (questionnaire part 2 residential, question 22).*

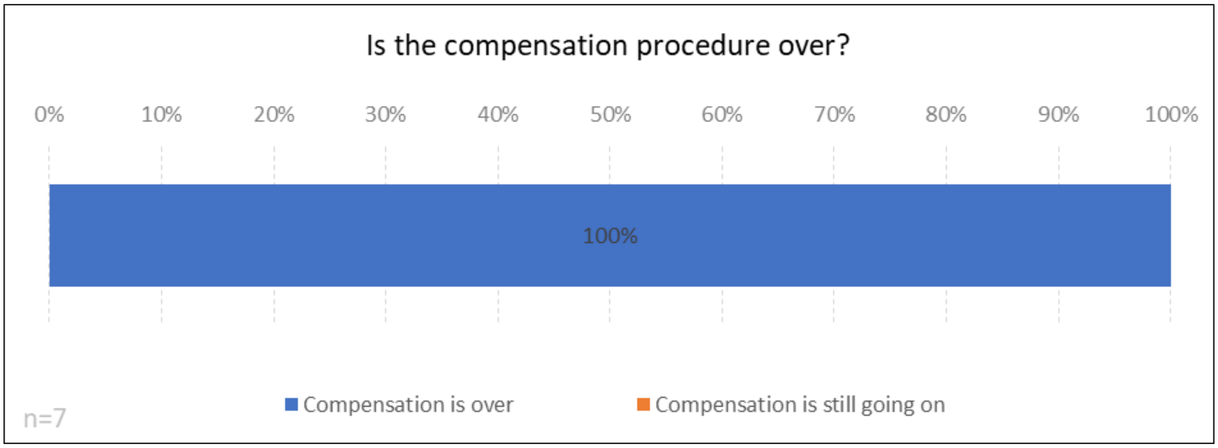



*Figure 217 Percentages of cases in which the compensation procedure regarding question 19 was over at the time of the interview, Germany (questionnaire part 2 residential, question 23).*

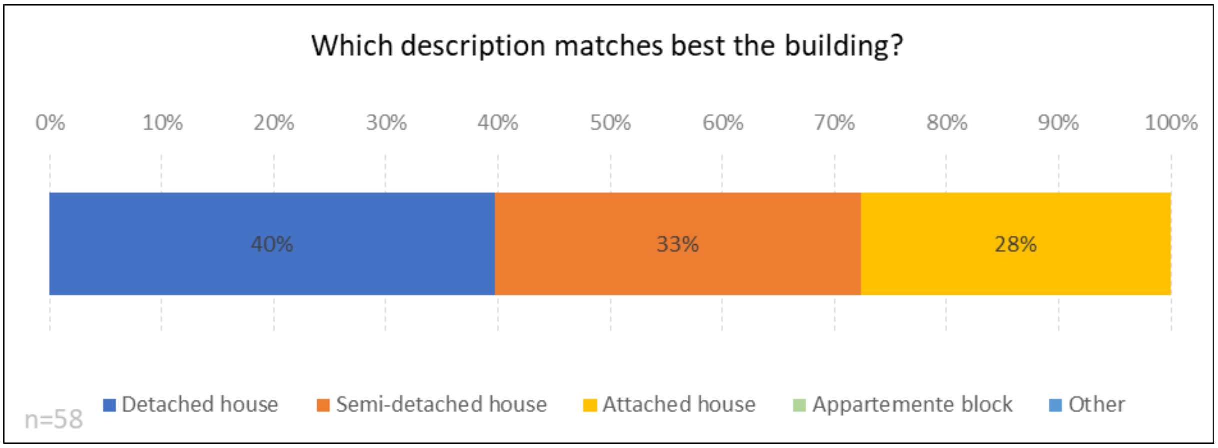



*Figure 218: Percentage of which types of buildings the participants live in, Netherlands (questionnaire part 2 residential, question 26).*

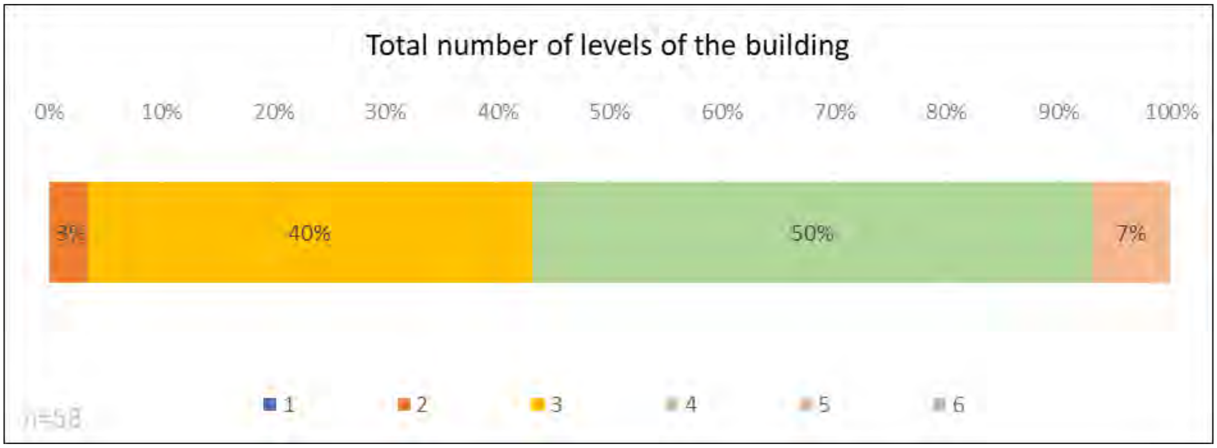
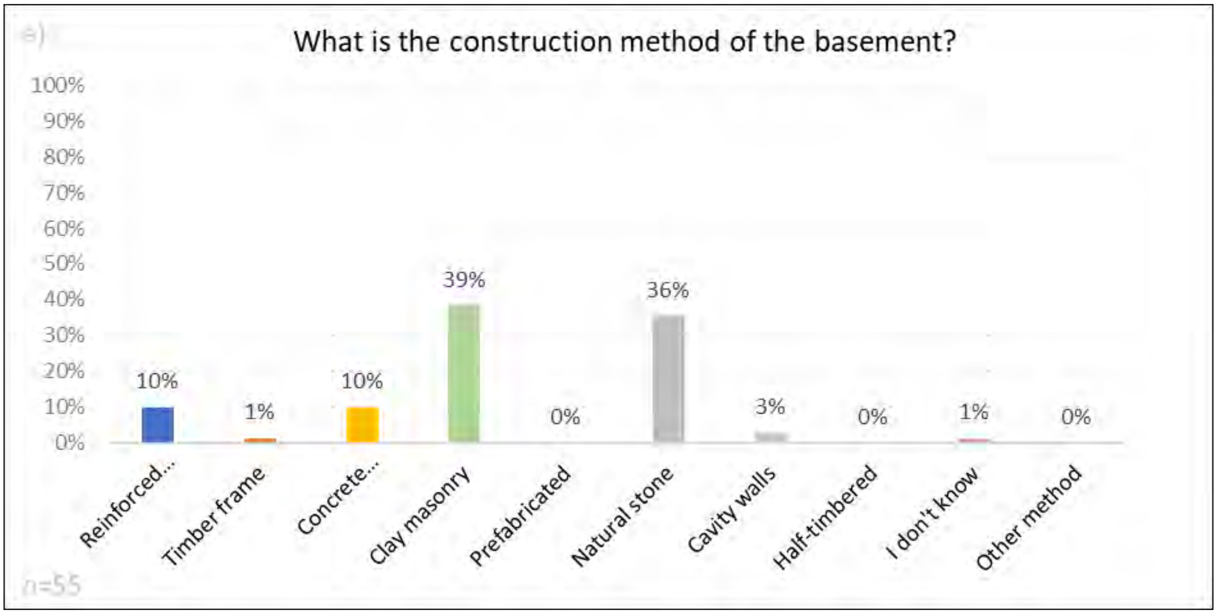
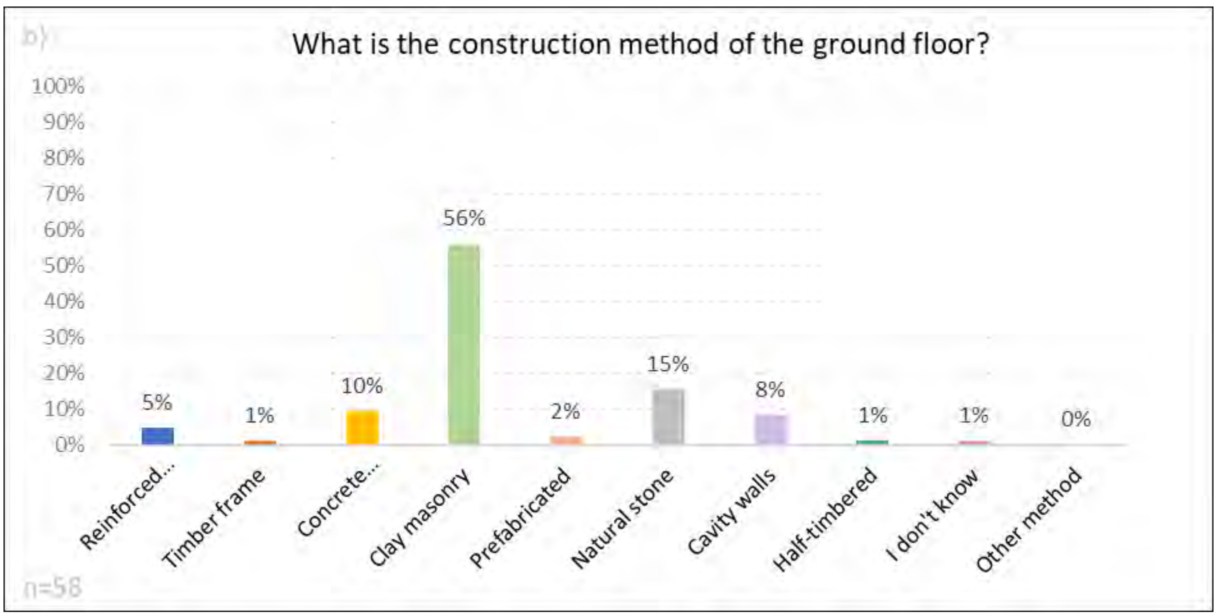



*Figure 219: Total number of levels of the buildings the participants live in, Netherlands (questionnaire part 2 residential, question 28).*


a)
What is the construction method of the basement?
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
10%
1%
10%
39%
0%
36%
3%
0%
1%
0%
Reinforced...
Timber frame
Concrete...
Clay masonry
Prefabricated
Natural stone
Cavity walls
Half-timbered
I don't know
Other method
n=55


b)
What is the construction method of the ground floor?
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
5%
1%
10%
56%
2%
15%
8%
1%
1%
0%
Reinforced...
Timber frame
Concrete...
Clay masonry
Prefabricated
Natural stone
Cavity walls
Half-timbered
I don't know
Other method
n=58

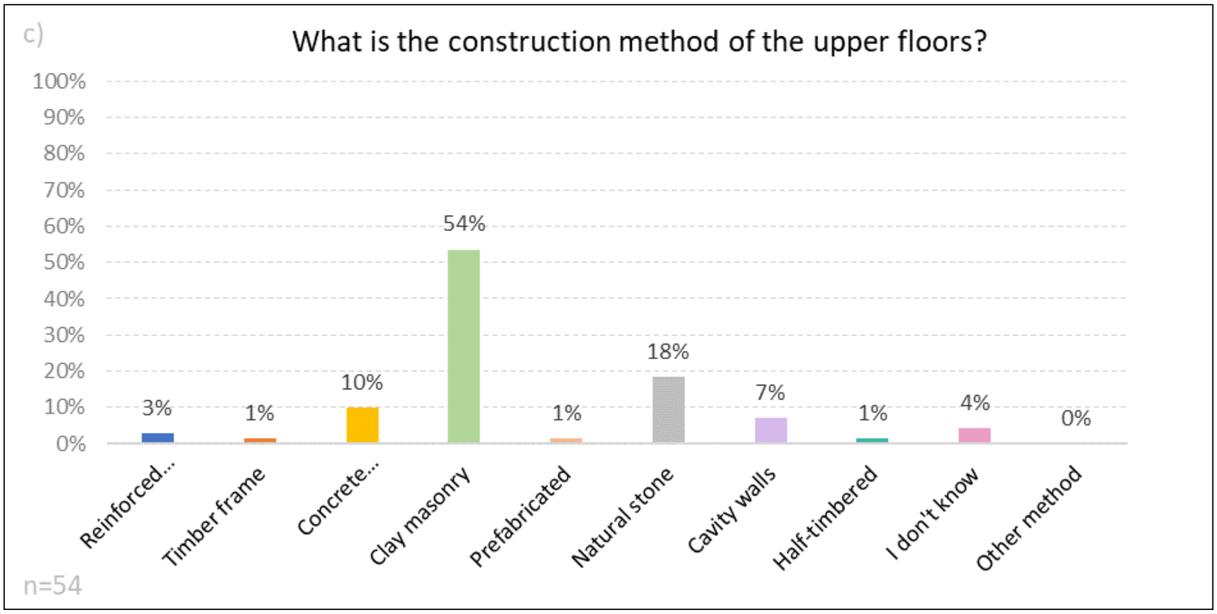



*Figure 220: Percentages of the construction methods of the a) basement, b) ground floor of the buildings the participants live in, Netherlands (questionnaire part 2 residential, question 29).*

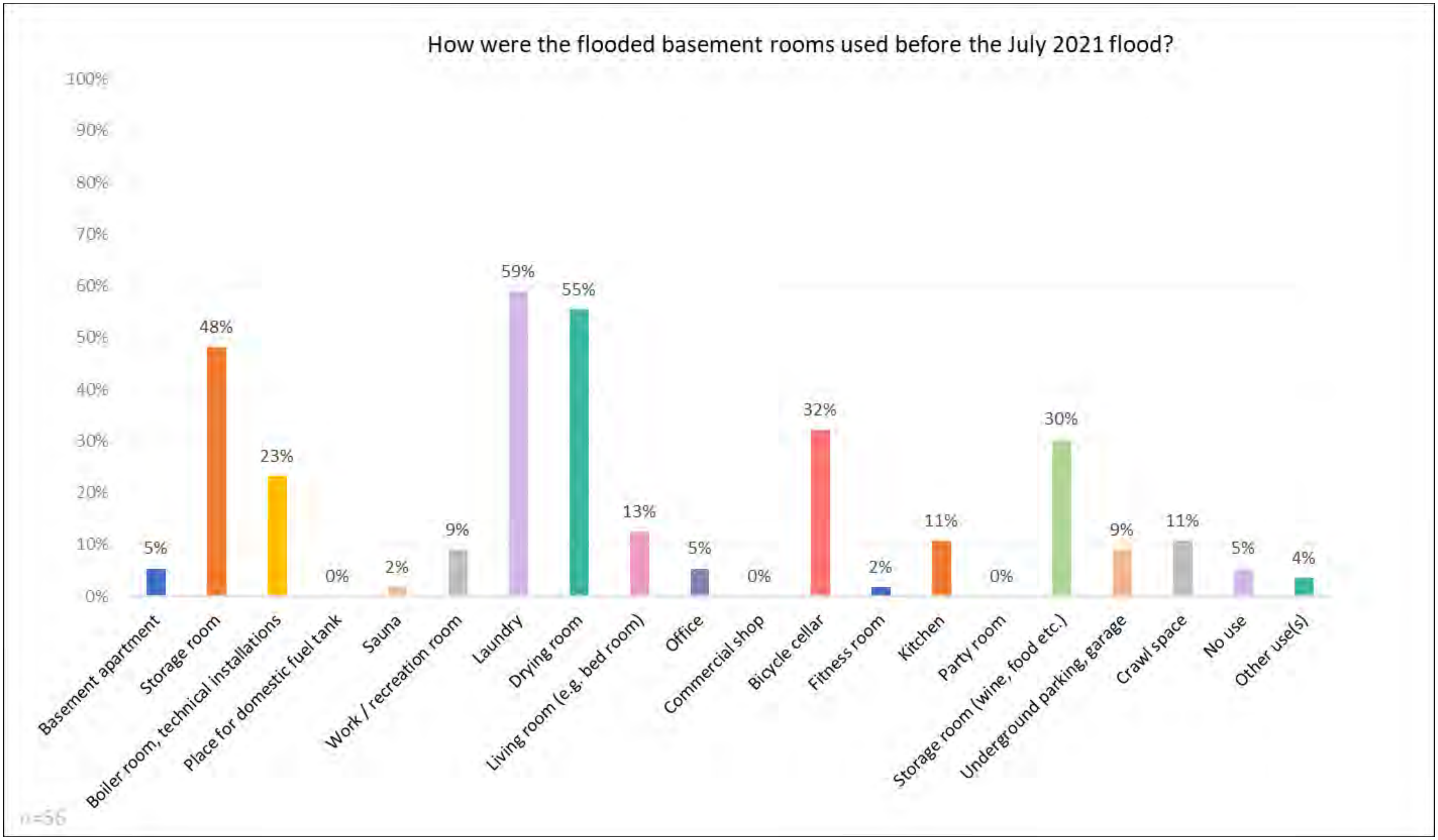



*Figure 221: Percentages of usage the basement had before the flood in July 2021, Netherlands (questionnaire part 2 residential, question 31)*

*Table 28: List of other uses of basement rooms before the flood in July 2021, Netherlands (questionnaire part 2 residential, question 32).*

| Abundance | Other uses of the basement rooms |
|---|---|
| 1 | Hobby space |

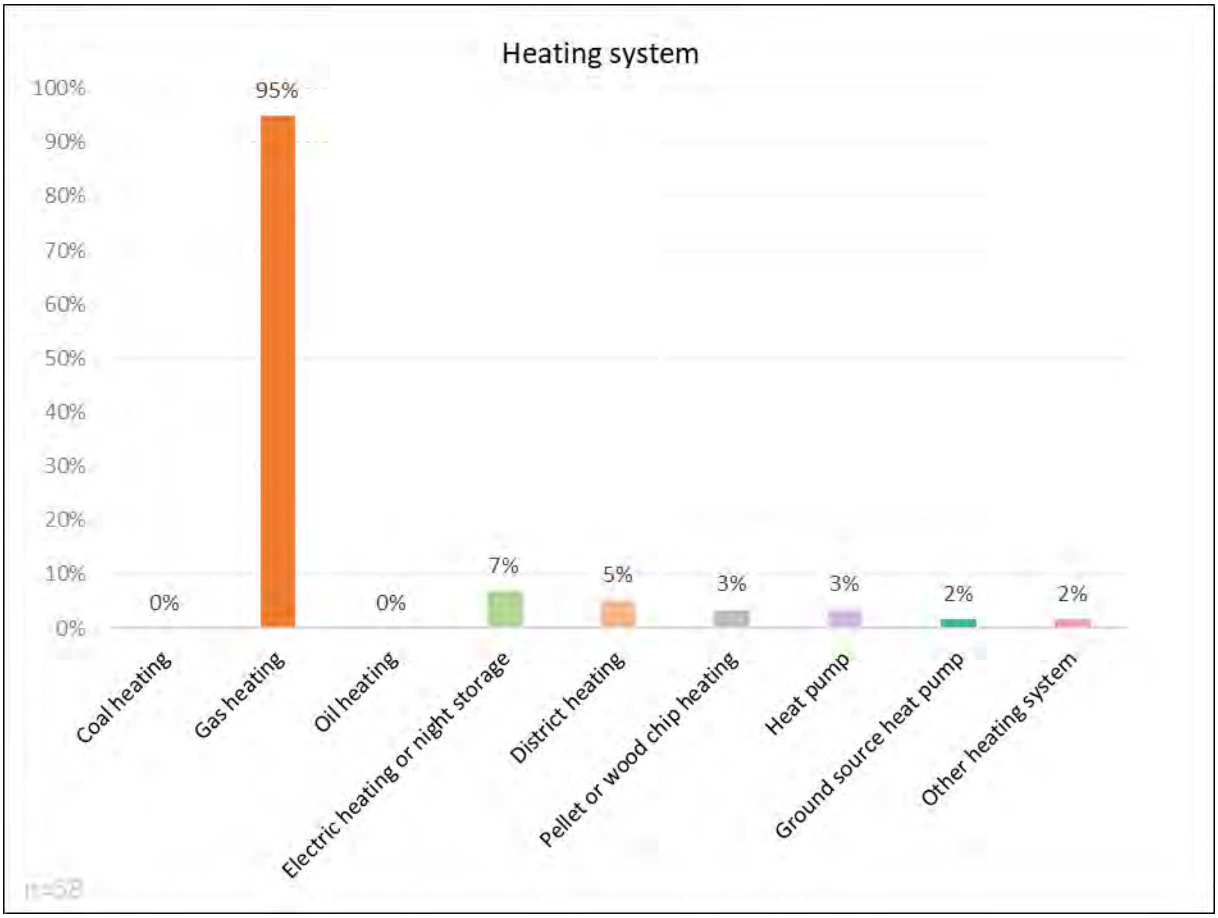



*Figure 222: Percentages of the heating systems of the participants, Belgium (questionnaire part 2 residential, question 35).*

*Table 29 : Other types of heating system than mentioned in question 35, Netherlands (questionnaire part 2 residential, question 36).*

| Abundance | Other heating system |
|---|---|
| 1 | Air conditioner |

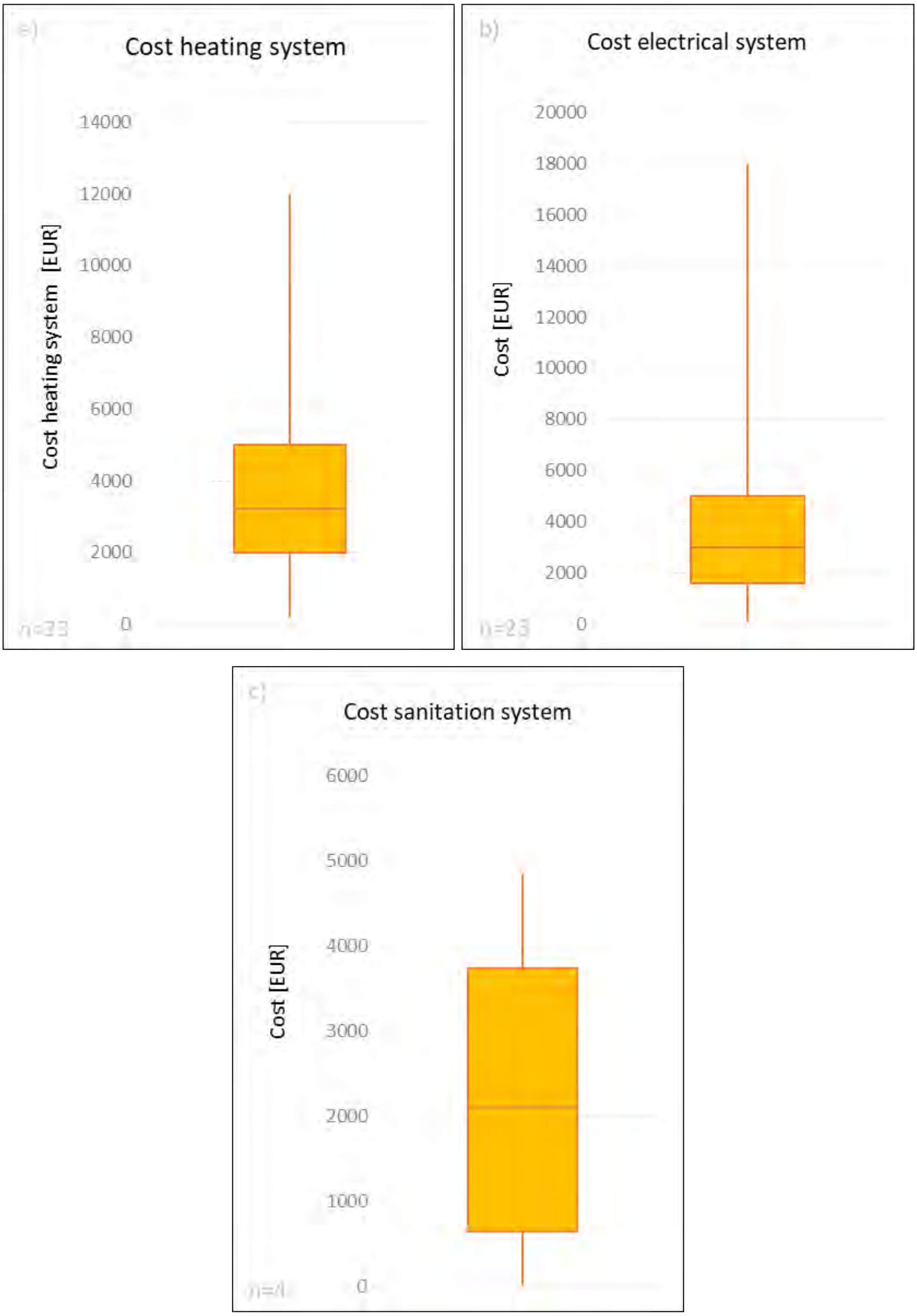



*Figure 223: Box plot of the total cost for repairing the a) heating system, b) electrical system and c) plumbing and sanitation system, Netherlands (questionnaire part 2 residential, question 39-41).*

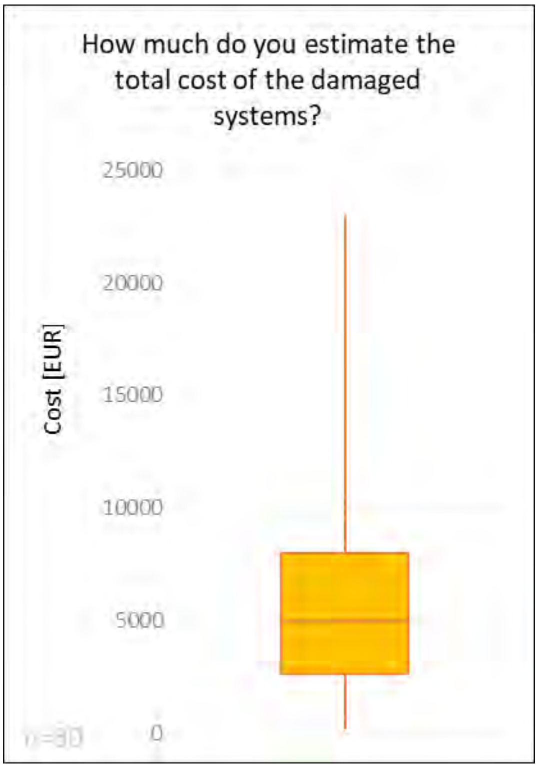



*Figure 224: Box plot of the total cost for repairing the damages systems, Netherlands (questionnaire part 2 residential, question 42).*

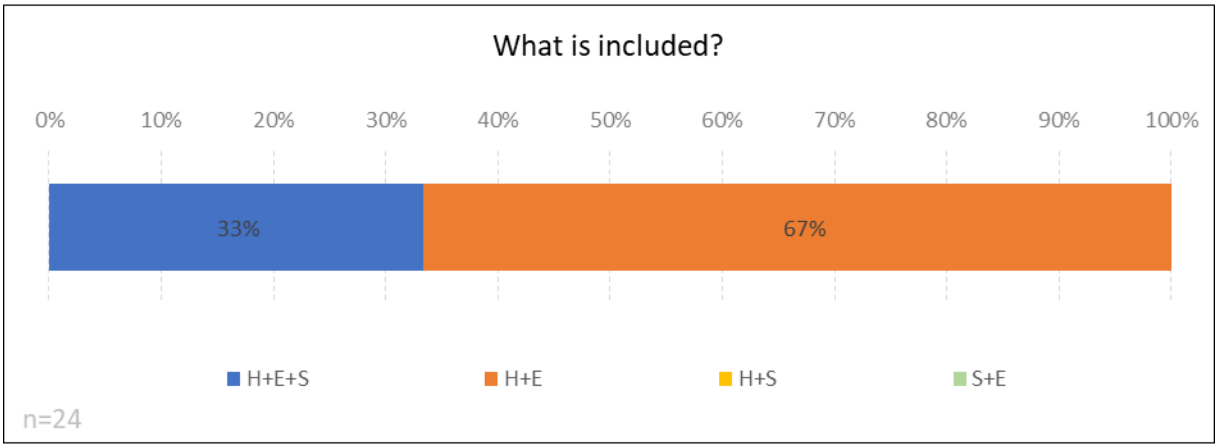



*Figure 225 : Percentage of which systems are included in the costs in question 42, Netherlands; H : heating system, E : electrical system, S : sanitation and plumbing system (questionnaire part 2 residential, question 43).*

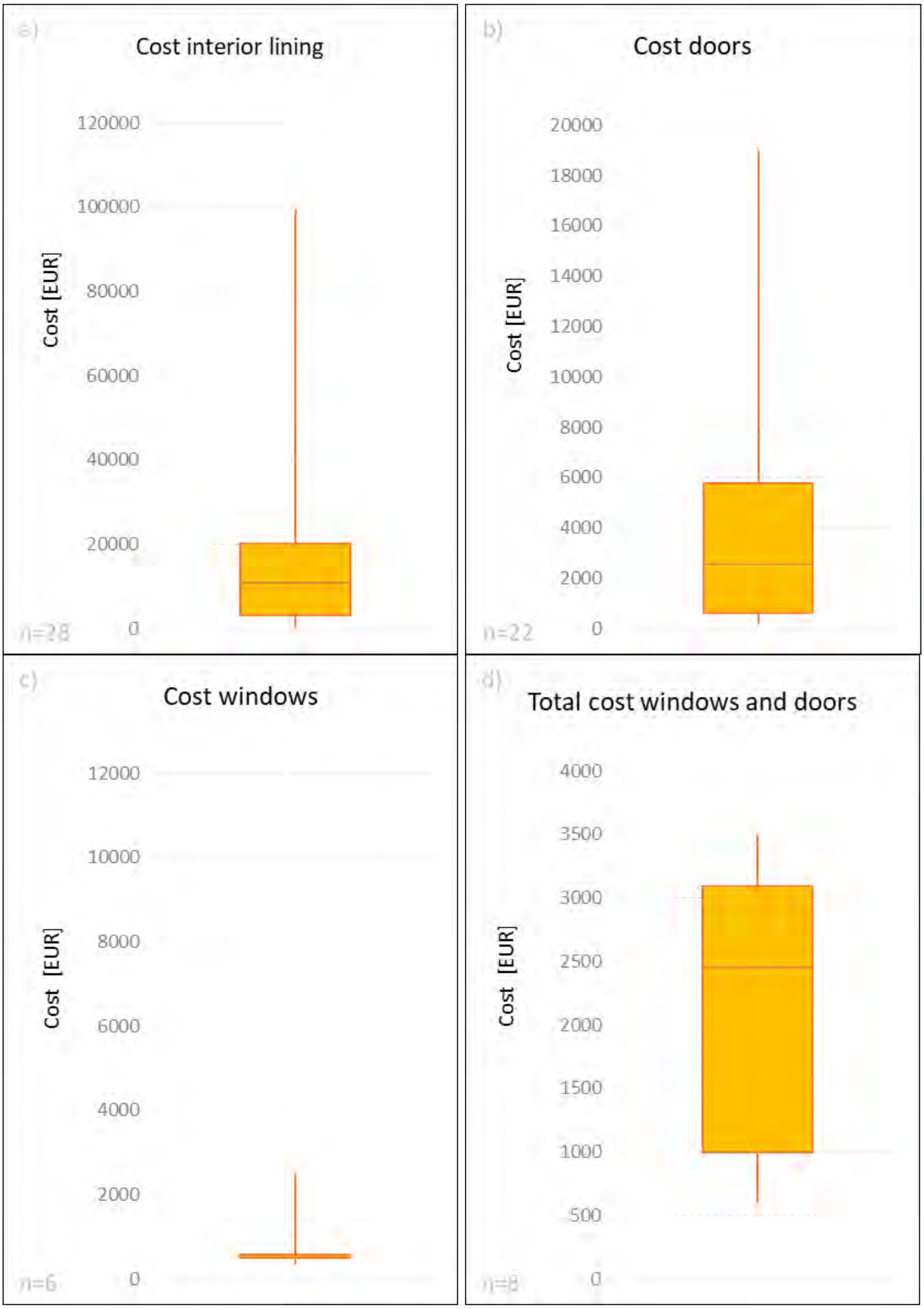



*Figure 226: Boxplots of the costs for a) interior lining, b) doors, c) windows and d) windows and doors, Netherlands (questionnaire part 2 residential, question 45-48).*

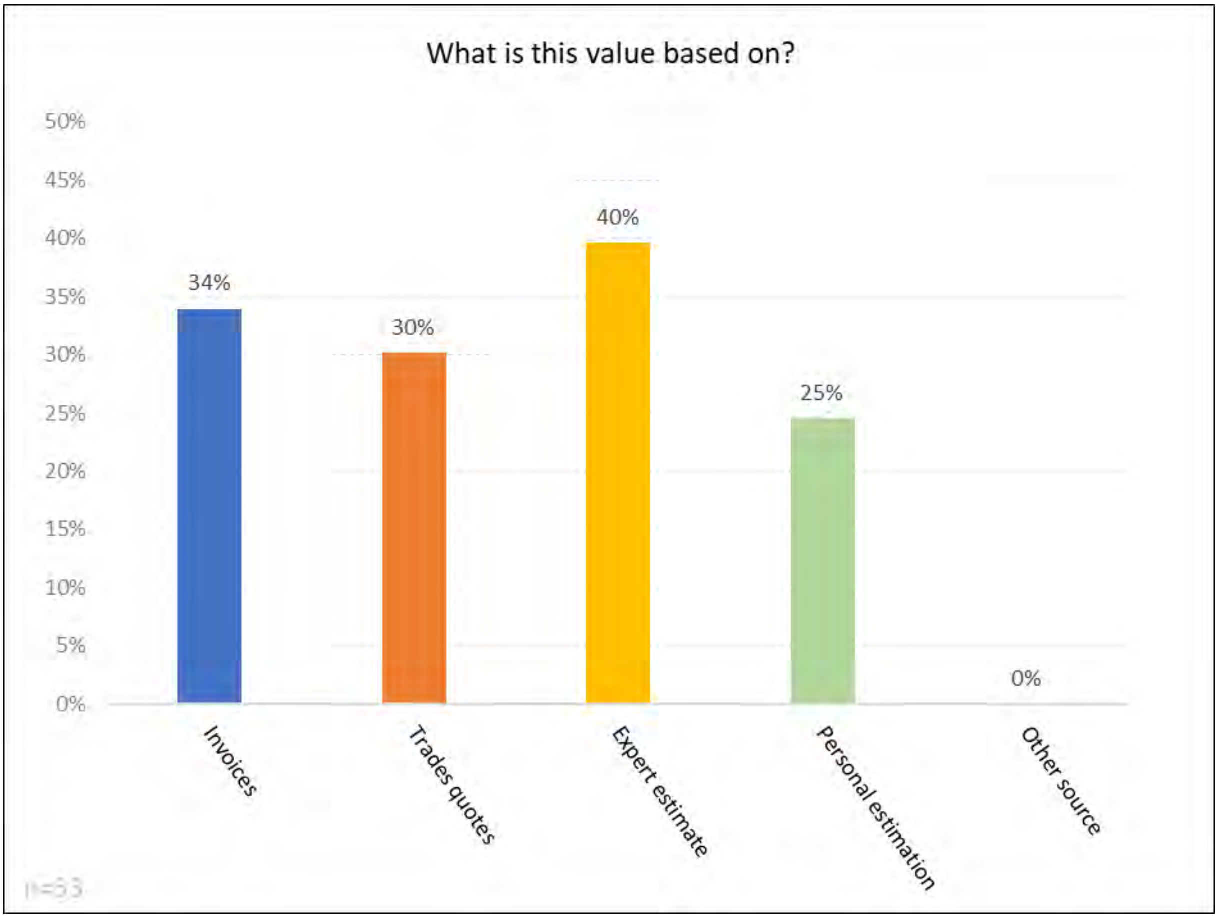



*Figure 227 : Percentages of basis for the given costs in question 50, Netherlands (questionnaire part 2 residential, question 51).*

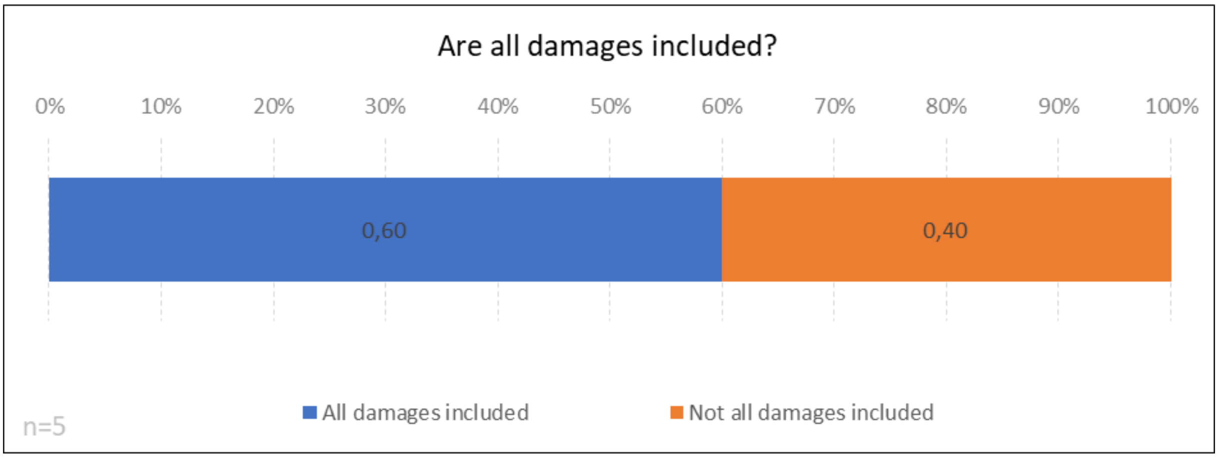



*Figure 228: Percentage of cases in which all damages are included in question 19, Netherlands (questionnaire part 2 residential, question 22).*

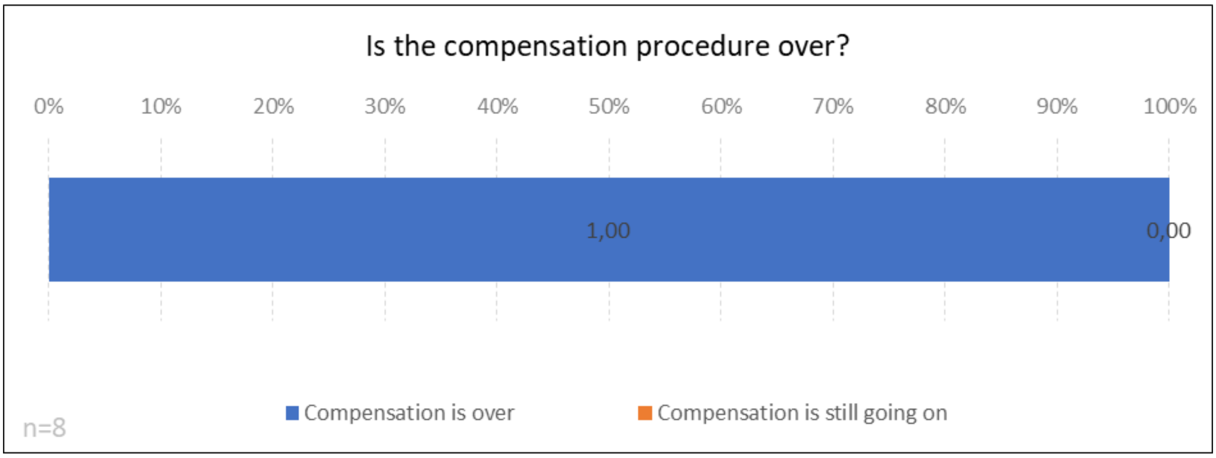



*Figure 229: Percentage of cases in which the compensation procedure regarding question 50 was over at the time of the interview, Netherlands (questionnaire part 2 residential, question 54).*


*Figure 230 : Boxplots of a) the hours for cleaning that were reported to the insurance and b) the financial compensation for the cleaning from the insurance, Netherlands (questionnaire part 2 residential, question 55-56).*

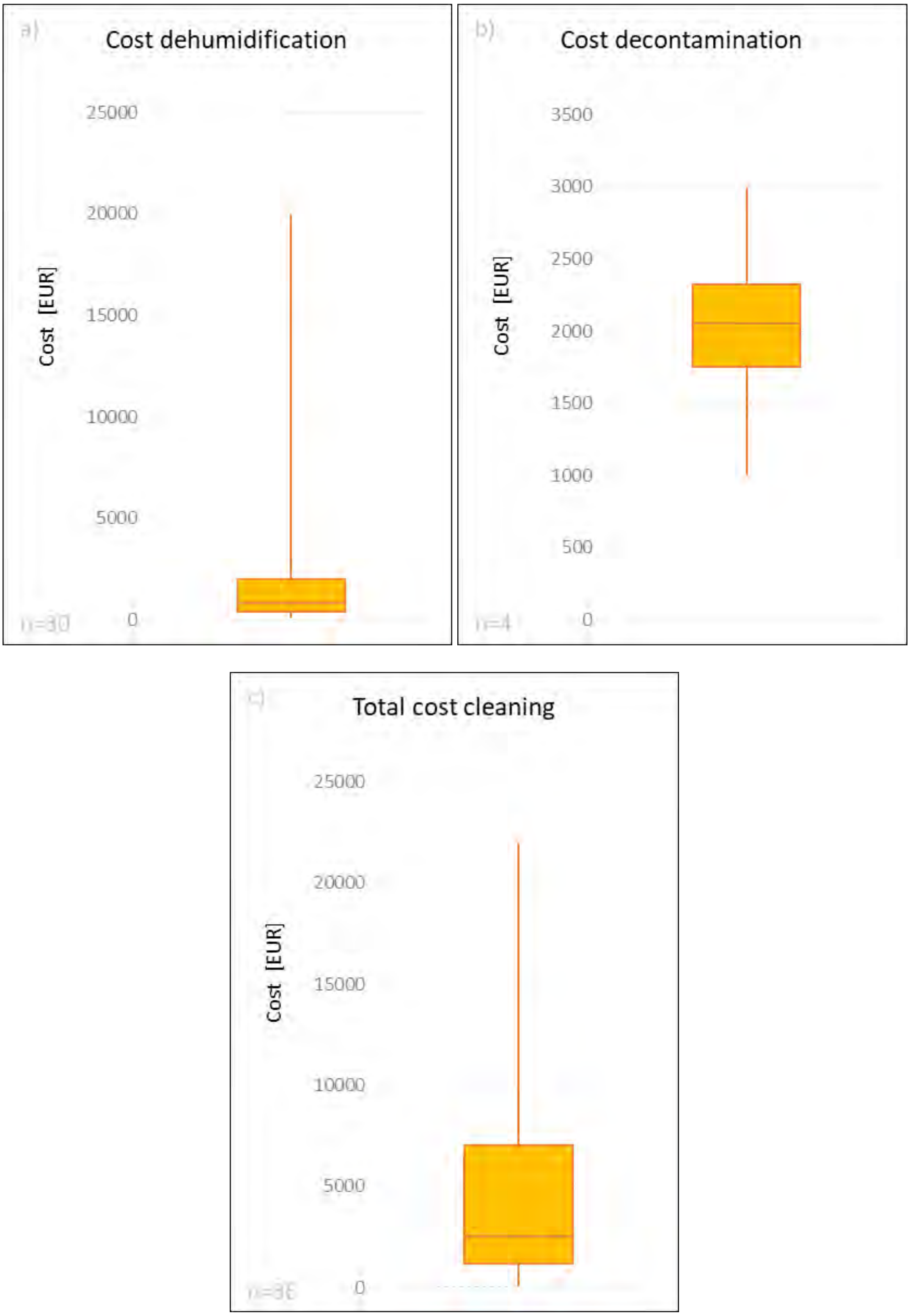



*Figure 231 : Boxplots of the costs for a) dehumidification, b) decontamination and c) cleaning in total, Netherlands (questionnaire part 2 residential, question 57-59).*

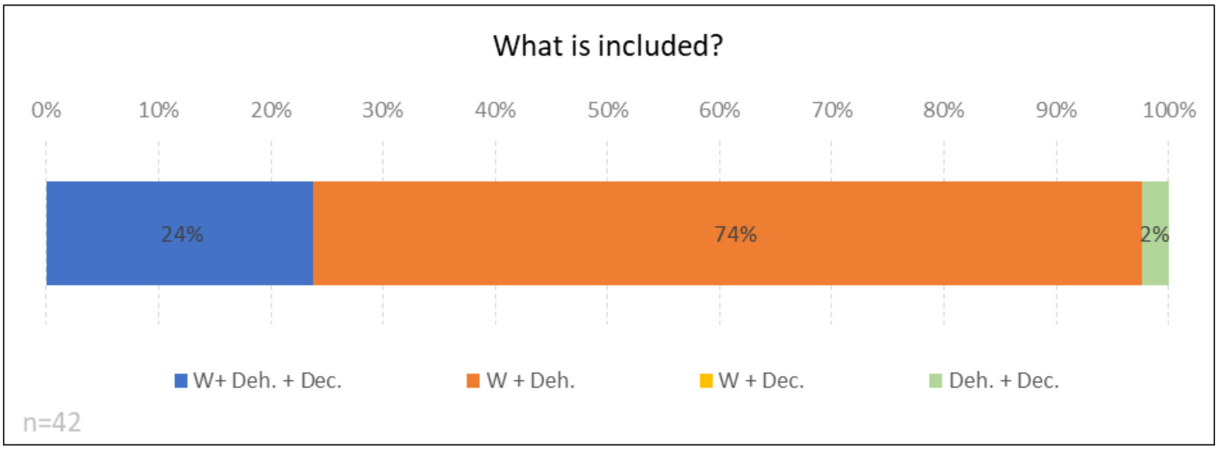



*Figure 232: Percentages of which costs are included in the value given in question 59, Netherlands (questionnaire part 2 residential, question 60).*

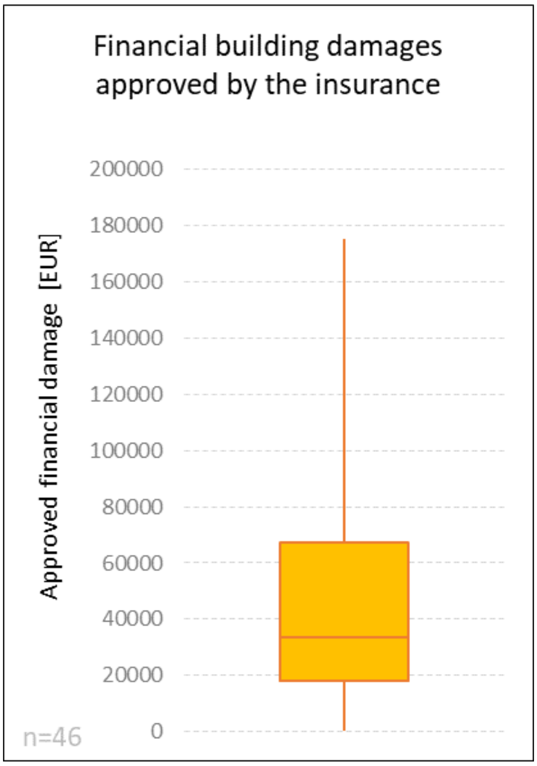



*Figure 233: Box plot of the approved amount of damage to or in the building by the insurance company, Netherlands (questionnaire part 2 residential, question 61).*

*Table 30 : Other types of financial help than mentioned in question 66, Netherlands (questionnaire part 2 residential, question 67).*

| Abundance | Other types of financial help |
|---|---|
| 1 | WTS (governmental help) did not want to cover because insurance company didn't want to cover the costs |
| 1 | Insurance claim is still going on |
| 1 | Garden costs are not compensated |
| 1 | |

| | |
|---|---|
| 1 | Entrance outside and tv system was not compensated |
| 1 | Part of damage not reimbursed, was partly estimated lower, no attention was paid to inflation |
| 1 | You don't receive new value |
| 1 | Horse riding hall and pavement not reimbursed |
| | Garden damage not approved |

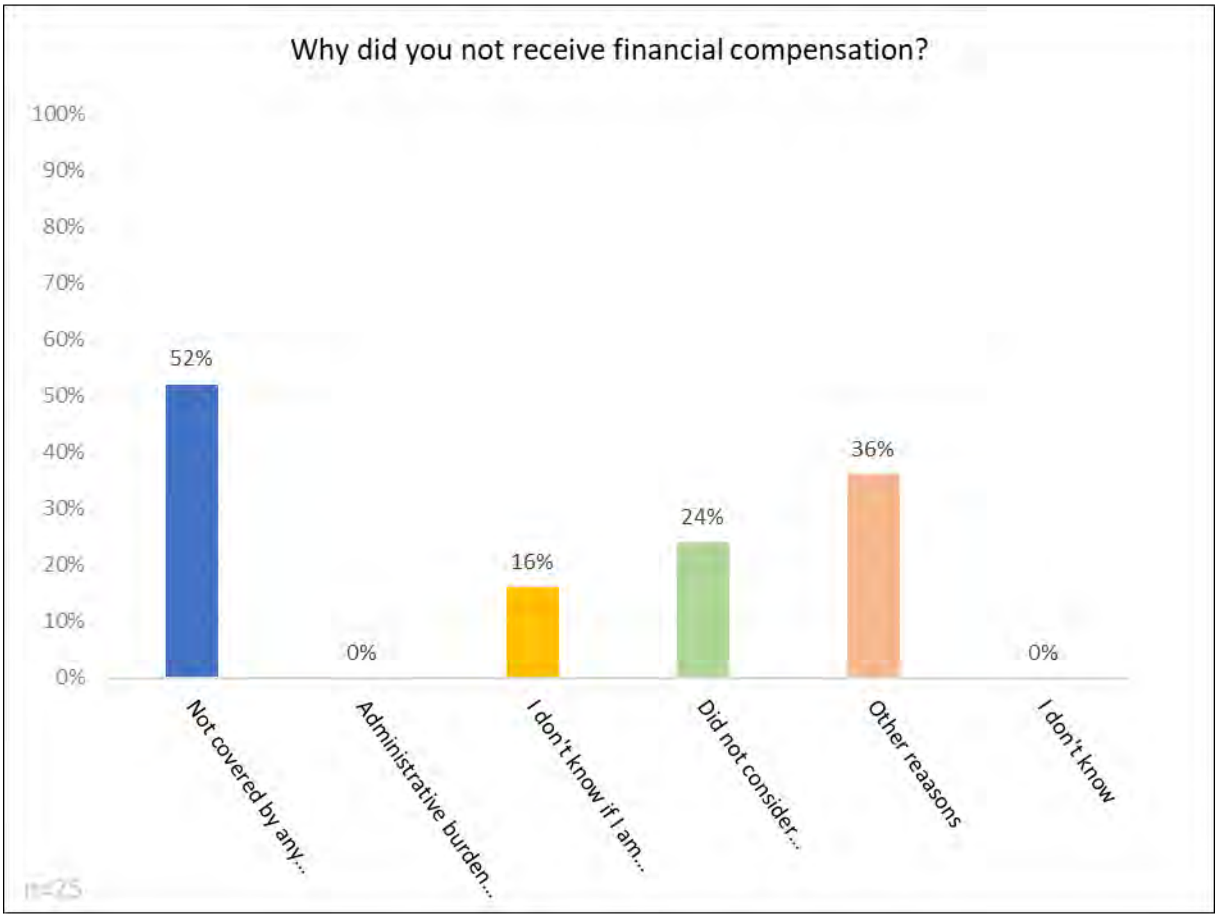



*Figure 234 : Percentages of reasons for not receiving financial help, Netherlands (questionnaire part 2 residential, question 68).*

*Table 31 : Other reasons for not receiving financial help than mentioned in question 68, Netherlands (questionnaire part 2 residential, question 69).*

| Abundance | Other reasons for not receiving financial help |
|---|---|
| 1 | WTS (governmental help) did not want to cover because insurance company didn't want to cover the costs. |
| 1 | Insurance claim is still going on |
| 1 | Garden costs are not compensated. |
| 1 | Entrance outside and tv system was not compensated. |

| | |
|---|---|
| 1 | Part of damage not reimbursed, was partly estimated lower, no attention was paid to inflation. |
| 1 | You don't receive new value. |
| 1 | Horse riding hall and pavement not reimbursed. |
| 1 | Garden damage not approved |

*Table 32 : Needs, participants still had at the time of the interview, Netherlands (questionnaire part 2 residential, question 74.)*

| Number | Which needs do you still have that have not yet been addressed? |
|---|---|
| 1 | Better communication needed, there was only Facebook in tv Limburg |
| 2 | Floors in basement are not fixed yet and cracks in the outer walls are present |
| 3 | Preventive approach of the problem is necessary. |
| 4 | Pleased about the insurance. Many weeds everywhere due to the flood |
| 5 | Prevention on individual level impossible |
| 6 | There has to be a solution, preventive. |
| 7 | WTS, must be better. |
| 8 | Concerns about non-existent solution. Individual adjustments are not sufficient to protect against these floods. |
| 9 | See below |
| 10 | Transparent communication plus more support from municipality |
| 11 | Price increase for materials and work will not be reimbursed. |
| 12 | Garden also a lot of damage. |
| 13 | Improve infrastructure/sewage |
| 14 | Insurance was not very forth going |
| 15 | Attached a letter written to the municipality |
| 16 | Damage to outside space should be covered by insurance policy in the future |
| 17 | Water storage across house is recently elevated with 1m, which caused insufficient storage. Also the ditches were completely overgrown resulting in less discharge capacity. |
| 18 | Garden should be covered, had damage of 500 euros |

*Table 33: Things that could have been done better in terms of information/support from government/own capabilities, Netherlands (questionnaire part 2 residential, question 75).*

| Number | What could have been done better in terms of information/support from government/ own capabilities? |
|---|---|
| 1 | Better warnings and NL alert |
| 2 | No aid by evacuation, no communication and no warnings |
| 3 | Issuing warnings |
| 4 | Nothing |
| 5 | Self involved by mental support initiated by the government |
| 6 | Warning system via the municipality |
| 7 | Information/warning, the magnitude of the disaster wasn't communicated |
| 8 | Crisis management/communication |
| 9 | More non-digital information for elders. |
| 10 | Wellicht nood alarm |
| 11 | Better information about financial help. What is reimbursed and by who. |
| 12 | Warning in advance. What can I do to prevent this? |
| 13 | Good organized, government fund had vague terms. |
| 14 | Warn! recommend water-resistant construction immediately after a disaster. |

| | |
|---|---|
| 15 | Was satisfied, but no warning. |
| 16 | Soil remediation by the government. |
| 17 | Ditch in front should have been excavated by the municipality, better information |
| 18 | Warning |
| 19 | Warnings |
| 20 | Everything, no info or warning |
| 21 | Faster and better alarm |
| 22 | The information came too late |
| 23 | The municipality has handled it well. |
| 24 | Emergency alarm should have been deployed. Authority must be local to activate this. |
| 25 | Better reimbursement with operational matters. |
| 26 | Aftercare |
| 27 | Warnings |
| 28 | Warnings before |
| 29 | Early warnings |
| 30 | Warnings on time |
| 31 | Warnings |
| 32 | Earlier warnings |
| 33 | Earlier warnings |
| 34 | Earlier warnings and solving problems |
| 35 | Feeling disinterest from municipality |
| 36 | Warnings and victim aid |
| 37 | Warnings and bad aid from the municipality |
| 38 | Aid from municipality was very poor. Neglect of water system |
| 39 | Surprise for everyone, also for the municipality. Aid after disaster was good. |
| 40 | Warnings |
| 41 | Warnings |
| 42 | Warnings |
| 43 | Warnings |

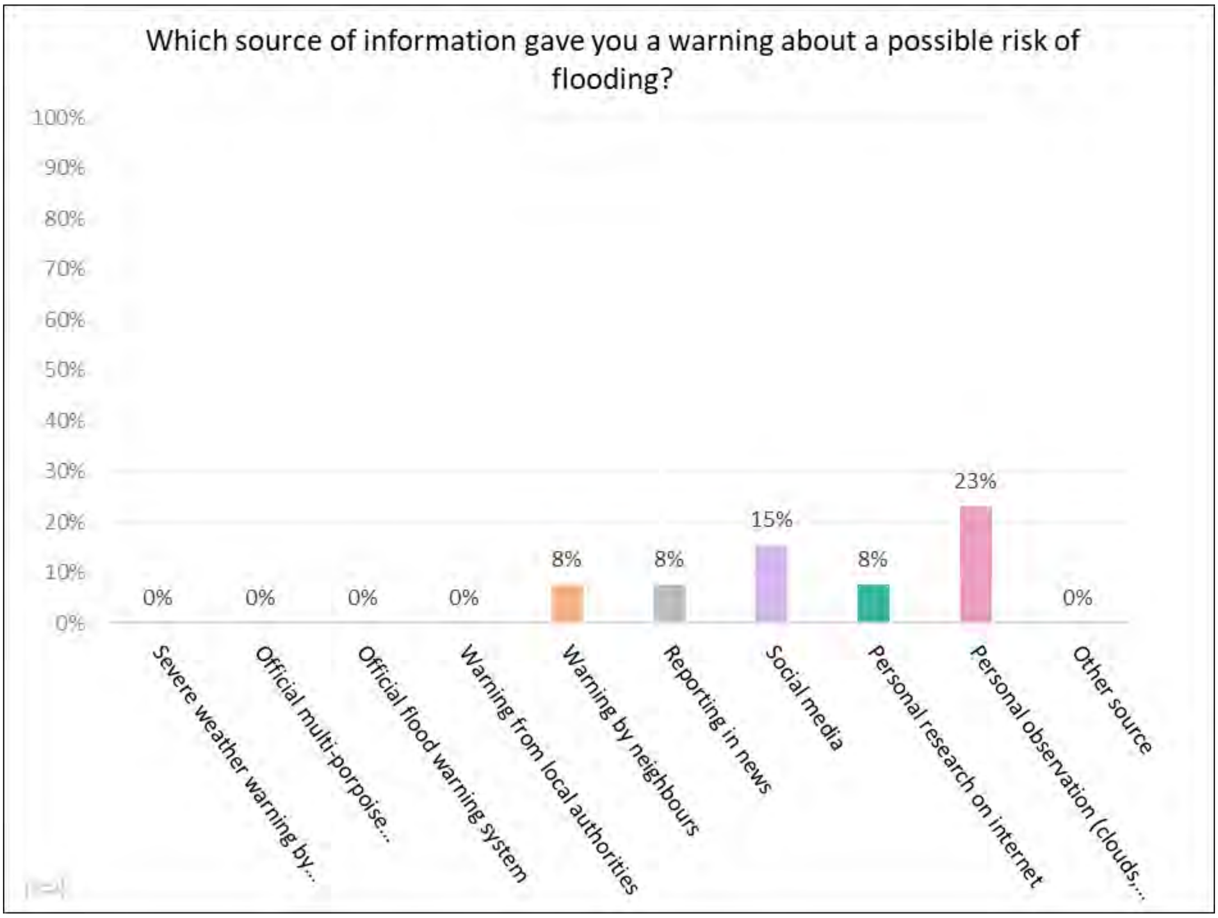



*Figure 235 : Percentages of warning sources, from which the participants received a warning about the possible risk of flooding, Netherlands (questionnaire part 2 residential, question 77).*

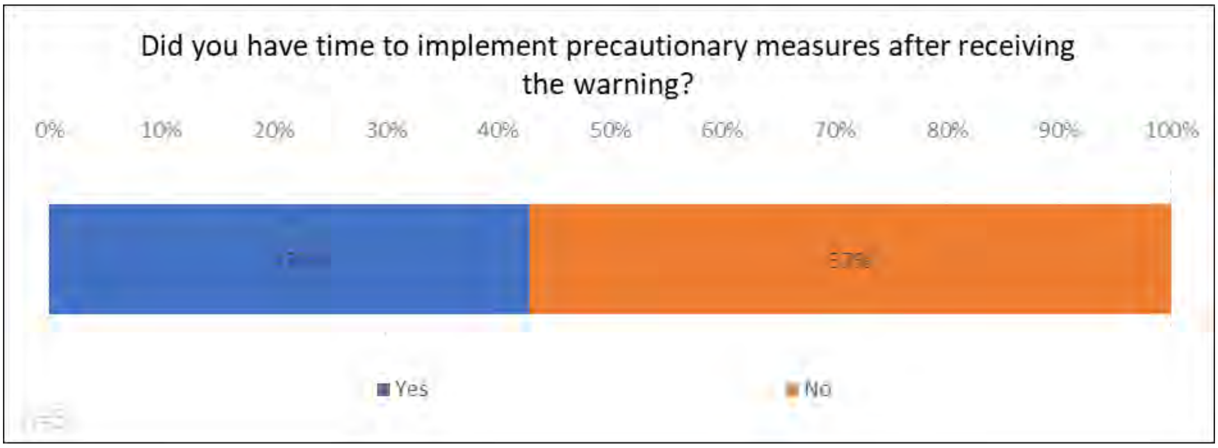



*Figure 236: Percentages of people who had time to implement precautionary measures after receiving the warning or not, Netherlands (questionnaire part 2 residential, question 80).*

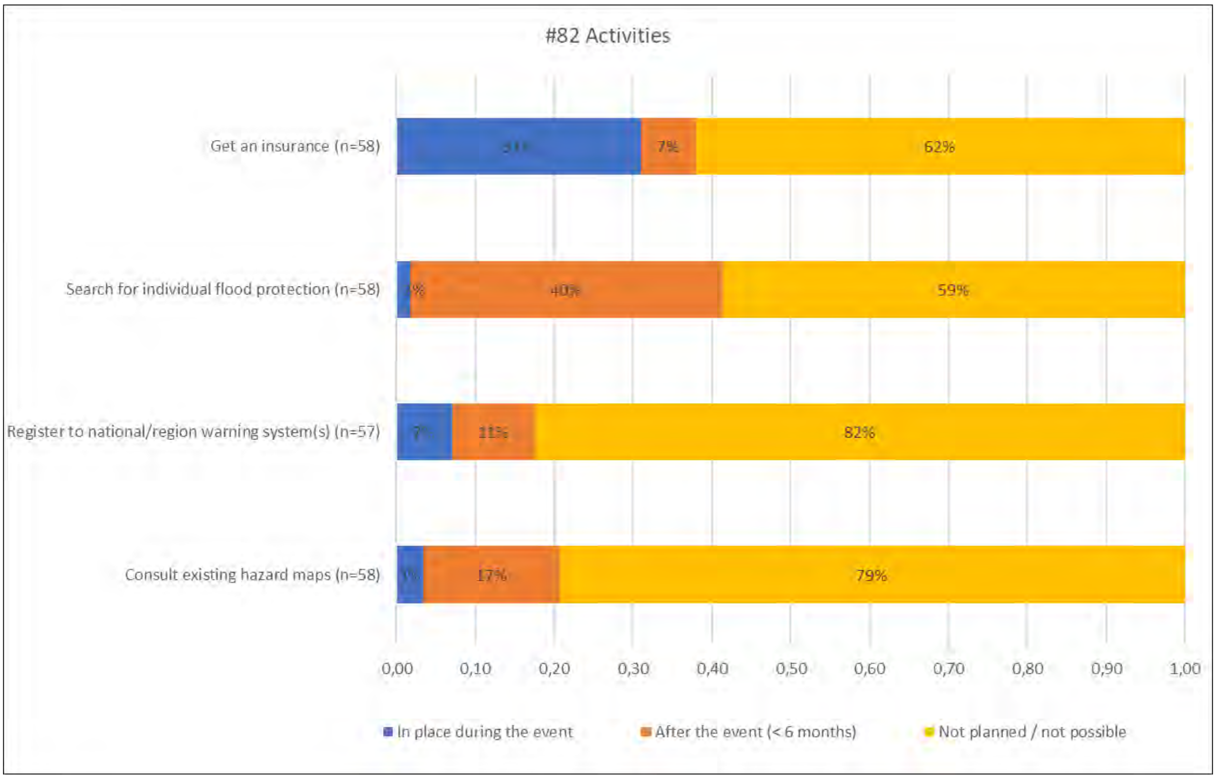
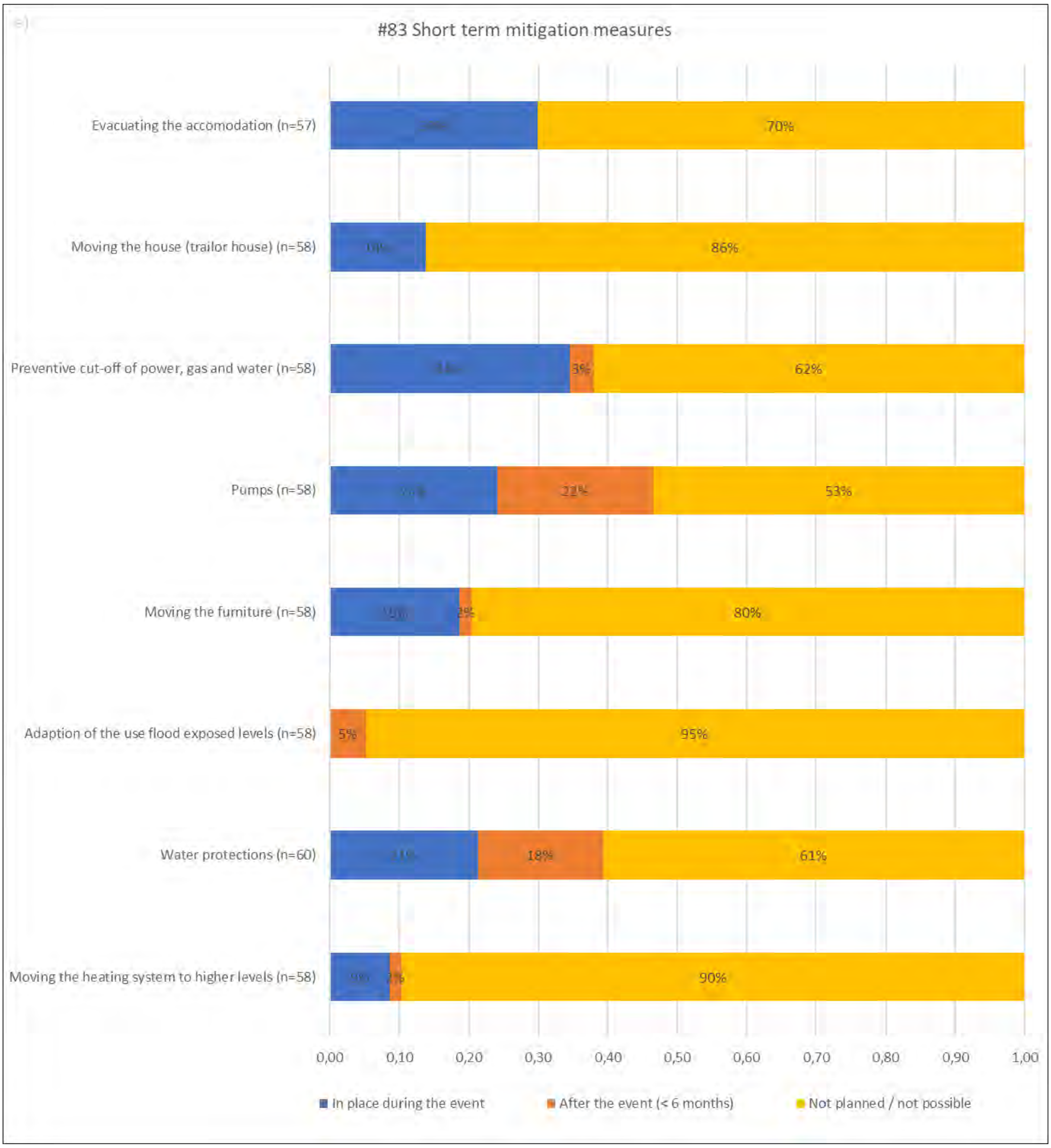



*Figure 237: Percentages of activities to be better informed of what to do in case of flood, Netherlands (questionnaire part 2 residential, question 82).*


#83 Short term mitigation measures
Evacuating the accomodation (n=57)
70%
Moving the house (trailor house) (n=58)
86%
Preventive cut-off of power, gas and water (n=58)
3%
62%
Pumps (n=58)
22%
53%
Moving the furniture (n=58)
2%
80%
Adaption of the use flood exposed levels (n=58)
5%
95%
Water protections (n=60)
18%
61%
Moving the heating system to higher levels (n=58)
2%
90%
0,00
0,10
0,20
0,30
0,40
0,50
0,60
0,70
0,80
0,90
1,00
In place during the event
After the event (< 6 months)
Not planned / not possible

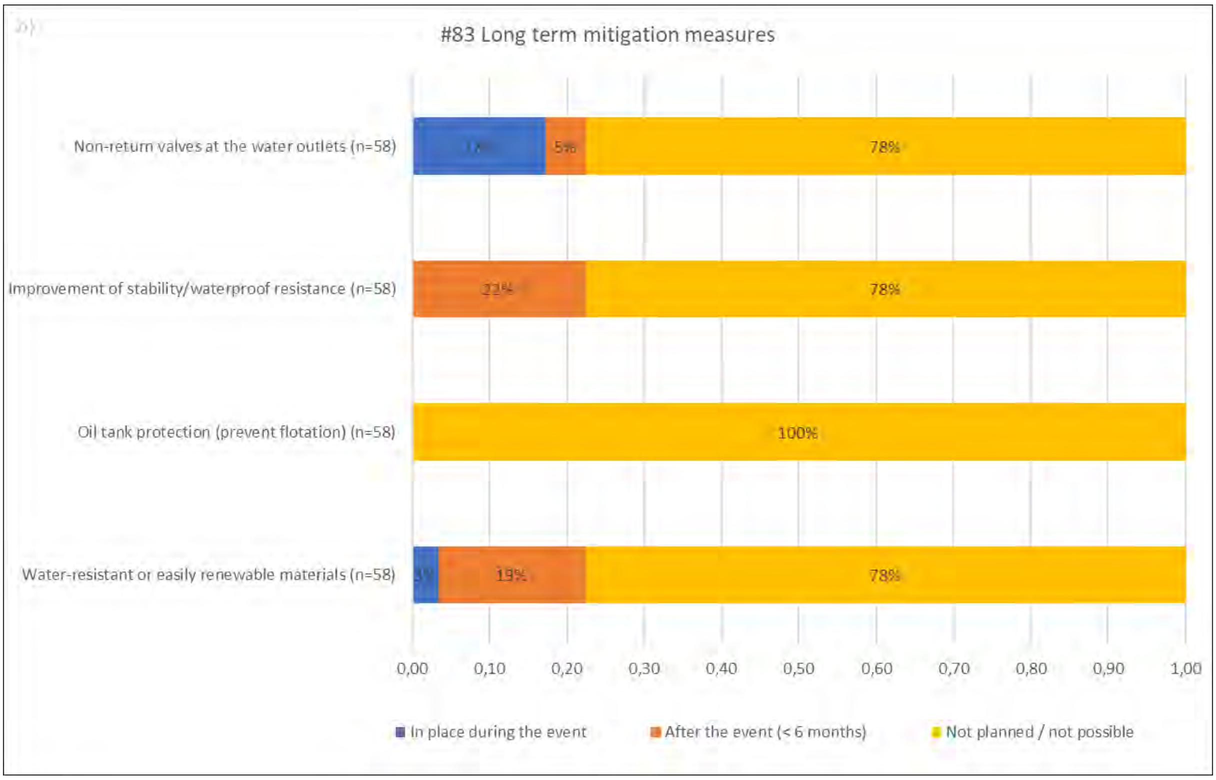



*Figure 238: Percentage of a) short term mitigation, b) long term mitigation measures, Netherlands (questionnaire part 2 residential, question 83).*


*Figure 239: Percentages of participants who had been affected by a flood event before July 2021 or not, Netherlands (questionnaire part 2 residential, question 85).*

## Part 2 Commercial

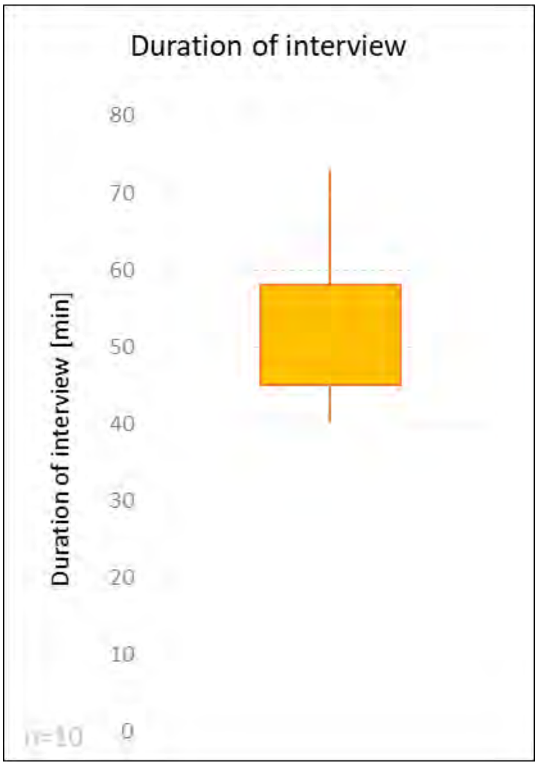



*Figure 240: Interview duration, Netherlands (questionnaire part 2 commercial, question 1).*

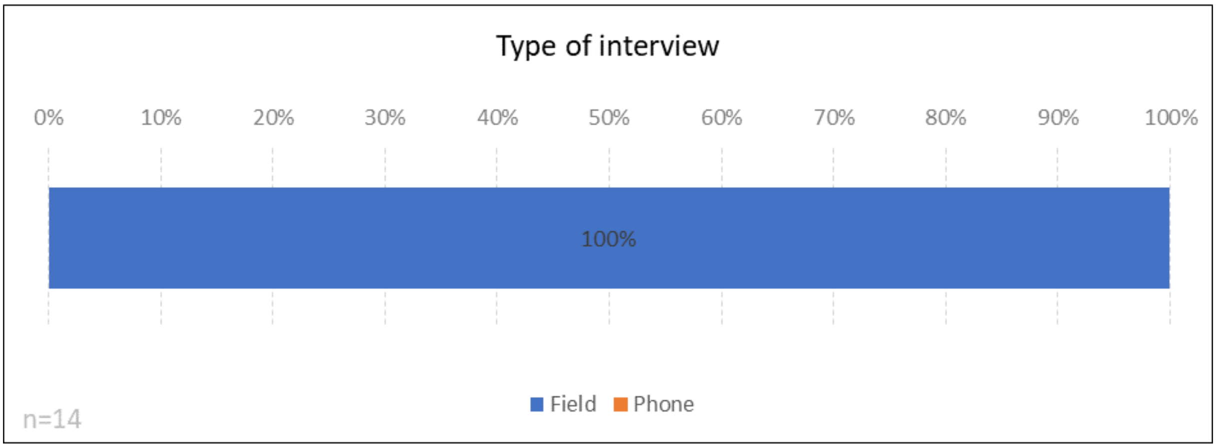



*Figure 241: Type of interview, Netherlands (questionnaire part 2 commercial, question 2).*

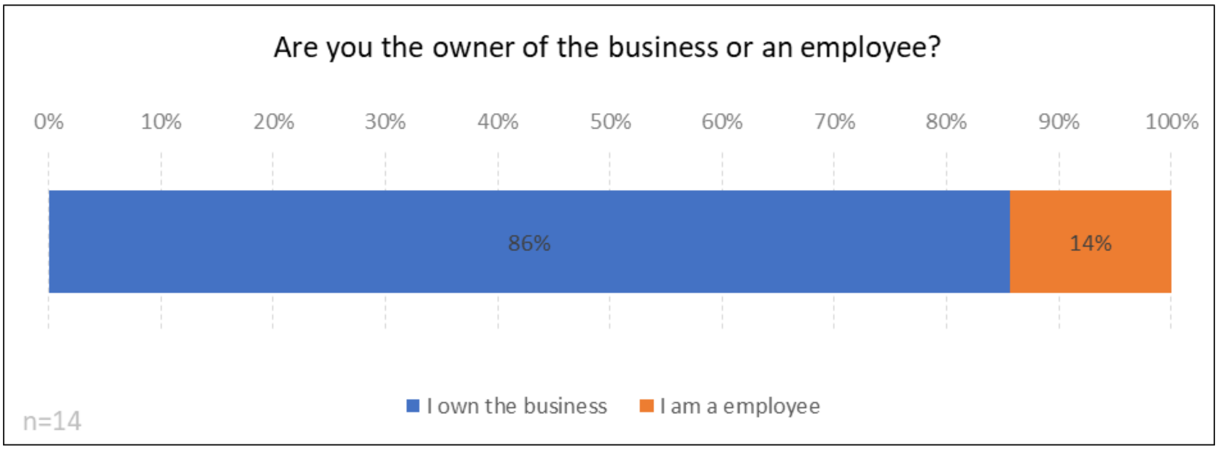



*Figure 242: Percentage of participants who are owner of the businesses or employees, Netherlands (questionnaire part 2 commercial, question 4).*

*Table 34: Other types of business than mentioned in question 5, Netherlands (questionnaire part2 commercial, question 6).*

| Abundance | Other reasons for not receiving financial help |
|---|---|
| 1 | Church |

*Table 35: Other causes of flooding than mentioned in question 7, Netherlands (questionnaire part2 commercial, question 8).*

| Abundance | Other reasons for not receiving financial help |
|---|---|
| 1 | Rain in the Ardennes |

*Table 36: Other uses of affected area than mentioned in question 9, Netherlands (questionnaire part2 commercial, question 10).*

| Abundance | Other reasons for not receiving financial help |
|---|---|
| 1 | Storage |
| 1 | Religious service |
| 1 | Recreation (swimming pool) + apartments |
| 1 | Basement |

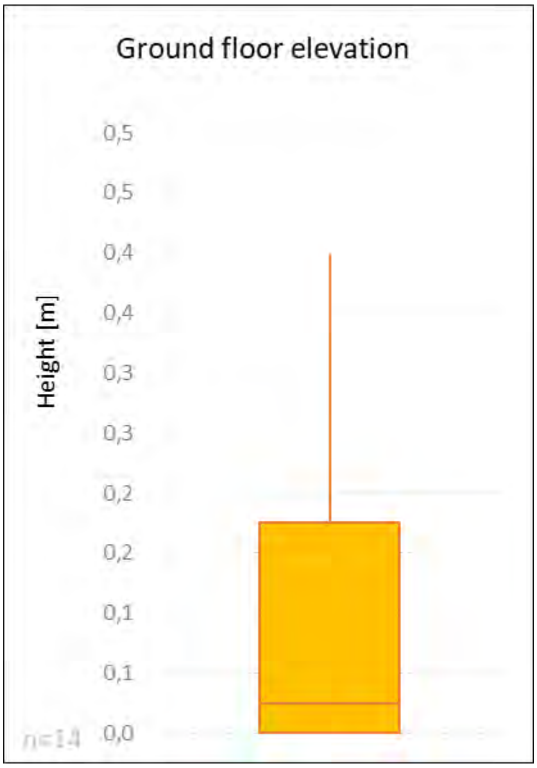



*Figure 243: Box plot of the elevation between street level and the ground floor of the buildings, Netherlands (questionnaire part 2 commercial, question 14).*

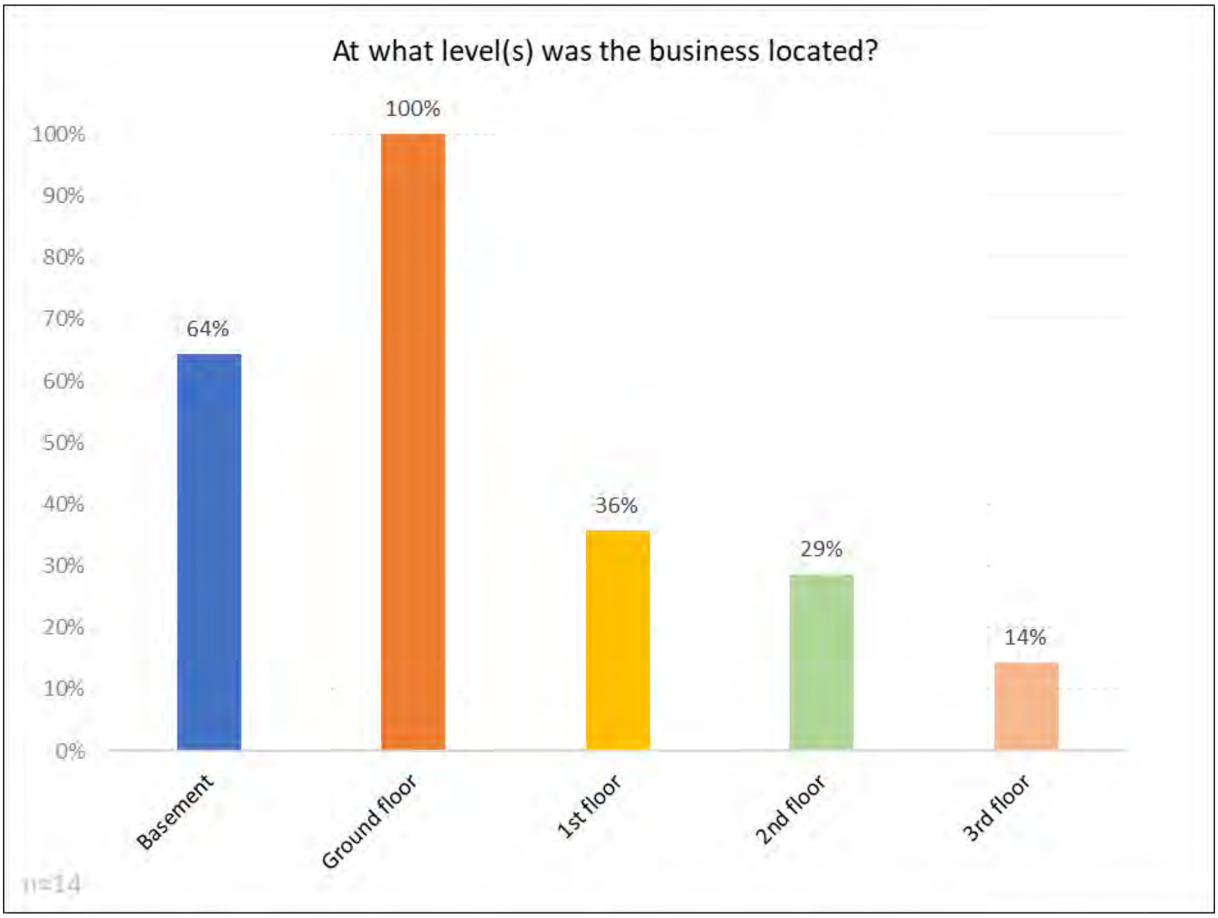



*Figure 244: Percentages on which level the businesses were located, Netherlands (questionnaire part 2 commercial, question 16).*

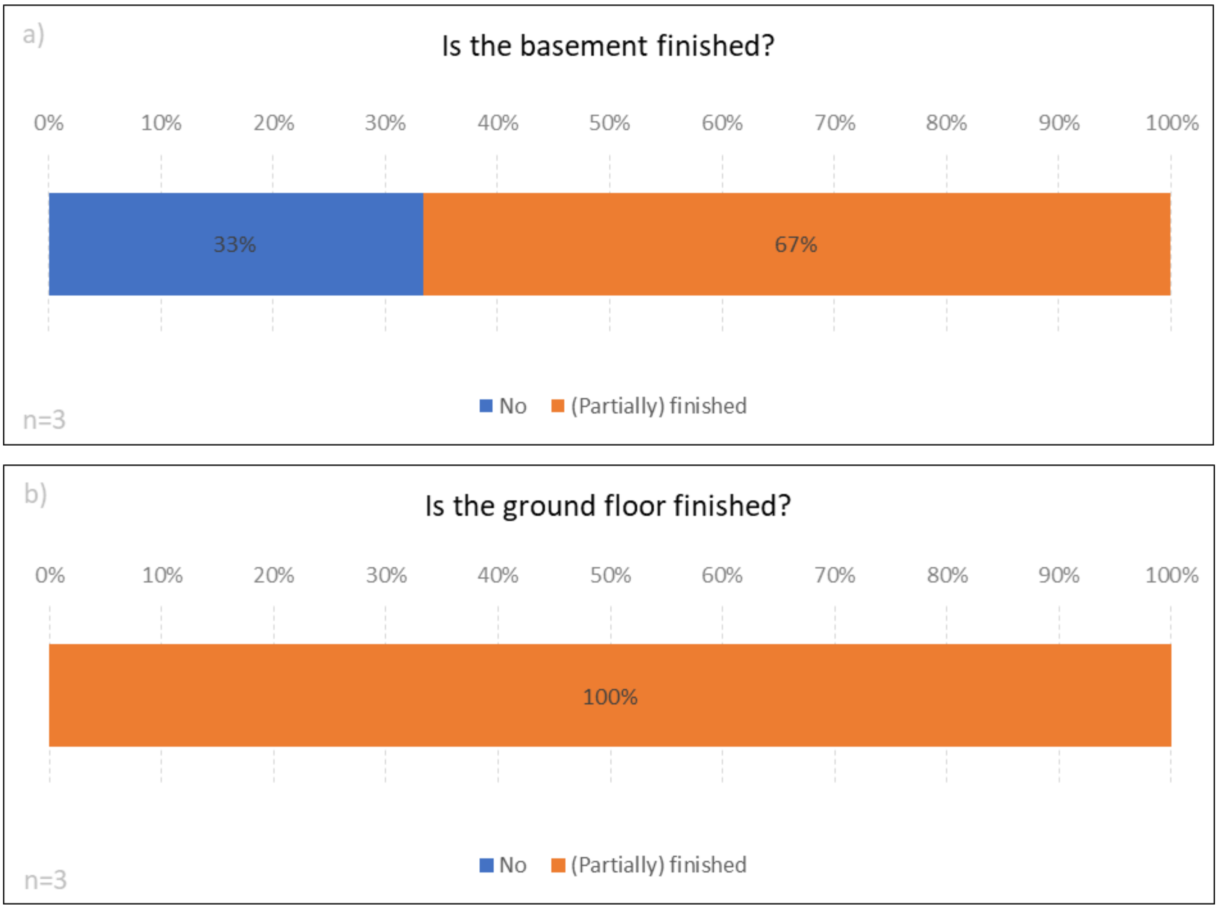



*Figure 245: Percentage of finished levels in the buildings of the participants, a) basement and b) ground floor, Netherlands (questionnaire part 2 commercial, question 17).*

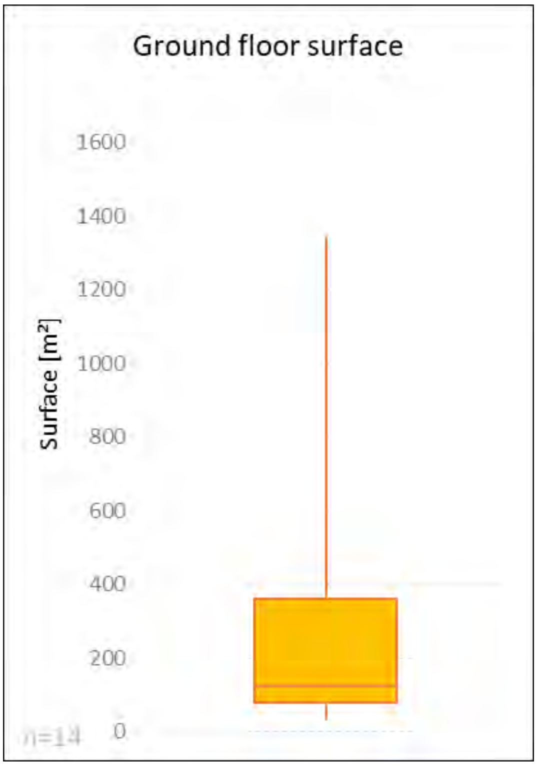



*Figure 246: Box plot of the ground floor surface of the buildings, Netherlands (questionnaire part 2 commercial, question 22).*

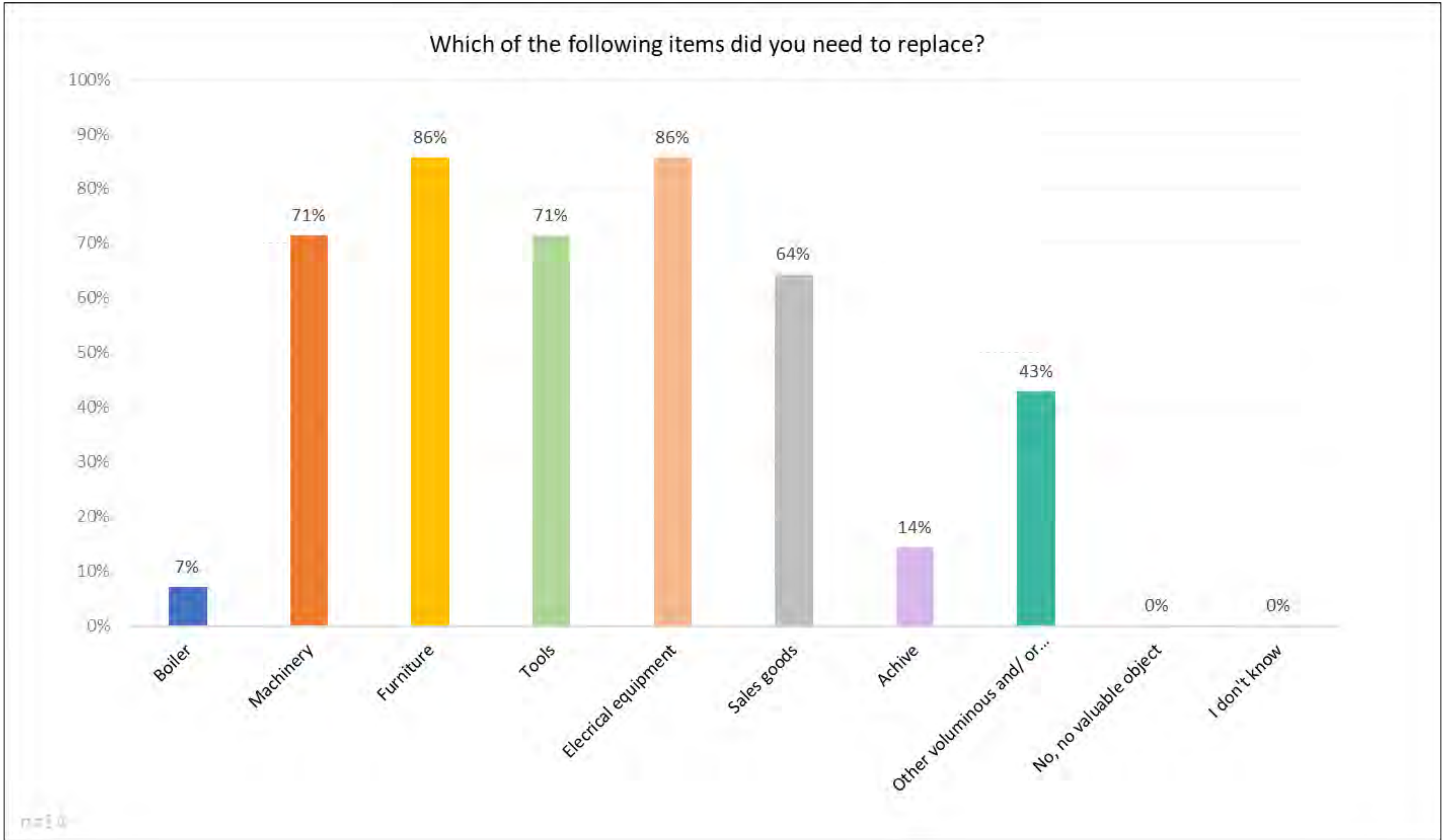



*Figure 247: Percentages of the business items, the participants did need to replace, Netherlands (questionnaire part 2 commercial, question 23)*

*Table 37: Other items, participants needed to replace than mentioned in question 23, Netherlands (questionnaire part2 commercial, question 24).*

| Abundance | Other reasons for not receiving financial help |
|---|---|
| 1 | Industrial kitchen equipment |
| 1 | Artwork (25 paintings, chandeliers) |
| 2 | Swimming pool/wellness equipment |
| 4 | Fridge(s) |
| 1 | Washing machine |
| 1 | Dryer |
| 1 | Chairs |
| 1 | Kitchen equipment |
| 1 | Pin automates |
| 1 | Stereo equipment |

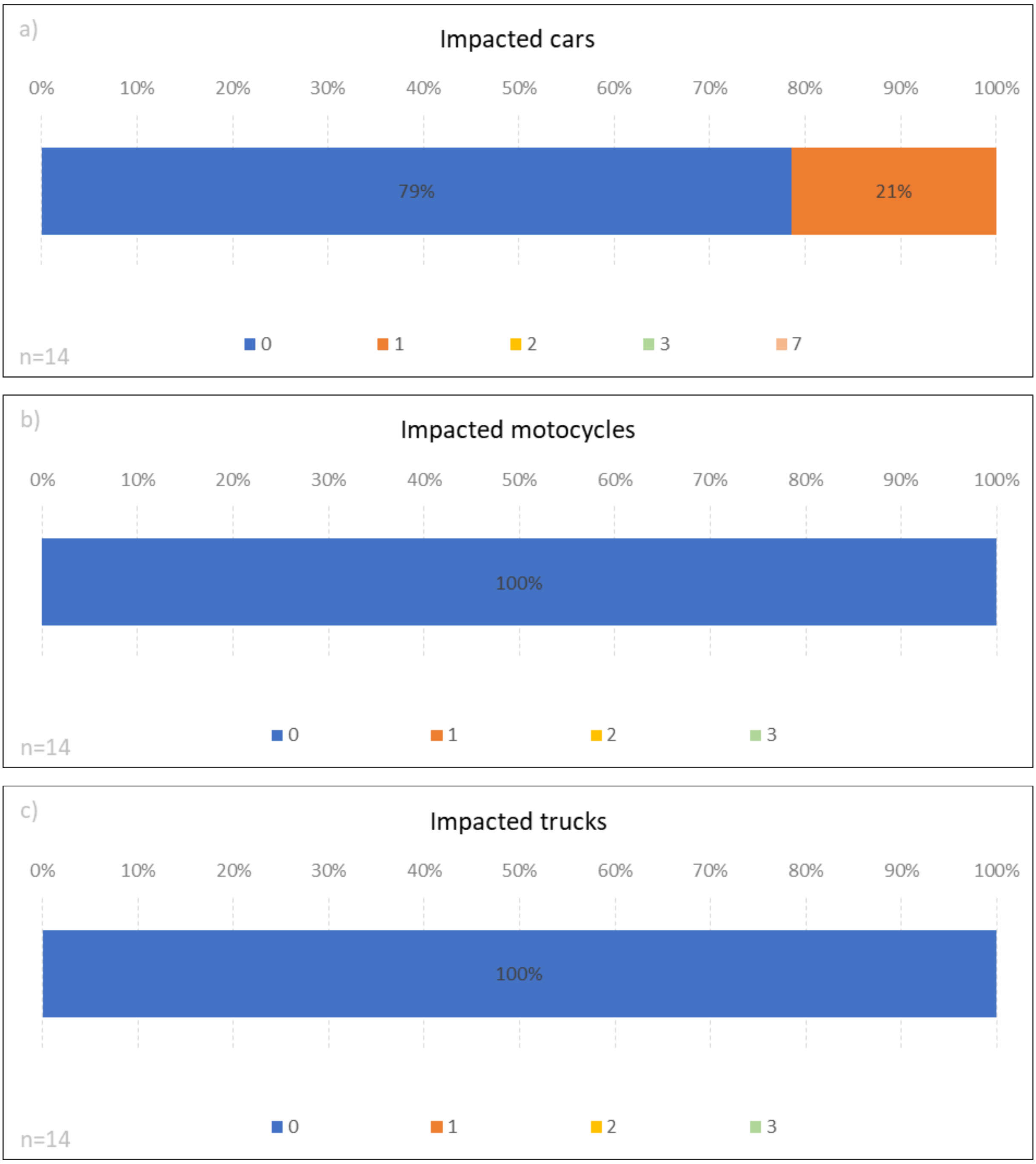



*Figure 248: Percentages of participants who had a) one/several car(s) or b) one/several motorcycles impacted by the flood, Netherlands (questionnaire part 2 commercial, question 25).*

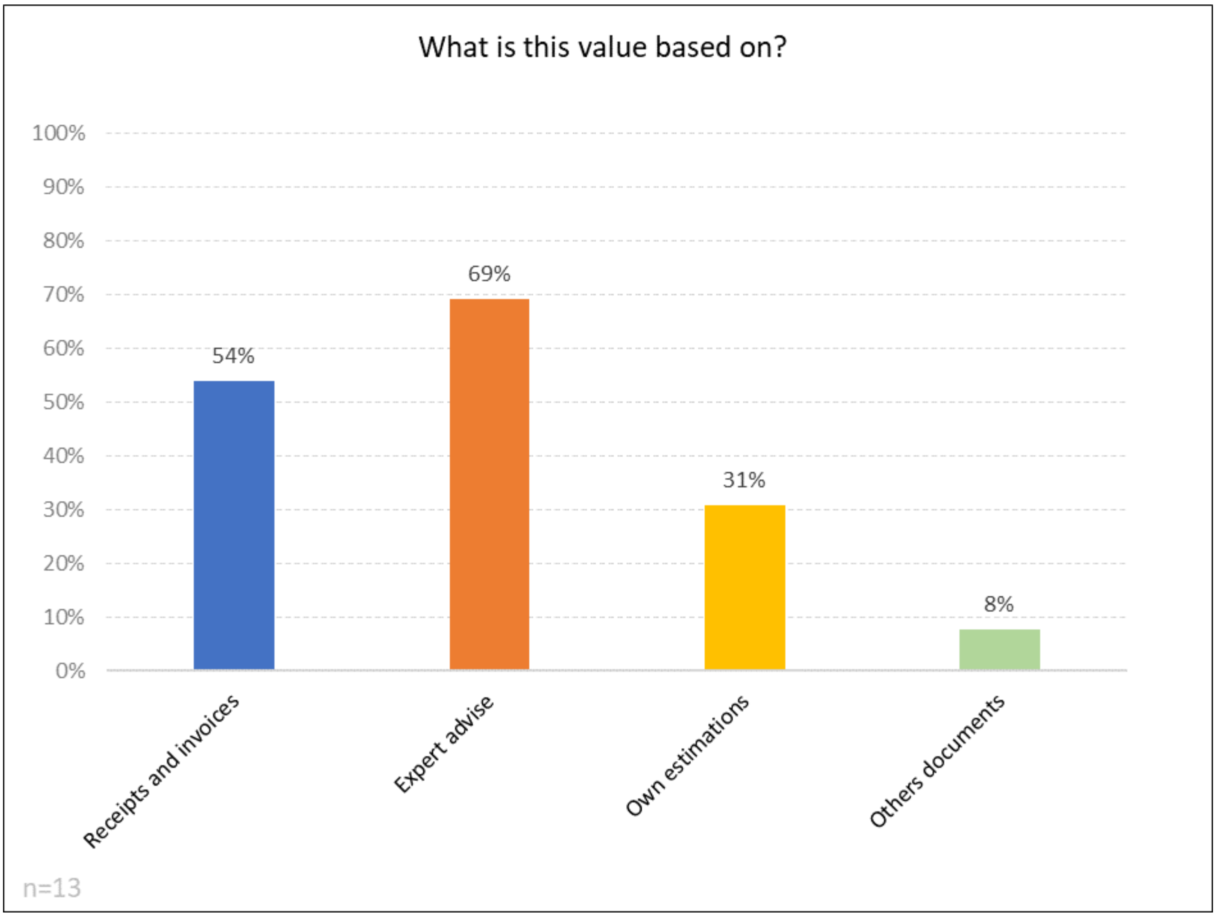



*Figure 249: Percentages of the base of the values from question 19, Netherlands (questionnaire part 2 commercial, question 27).*

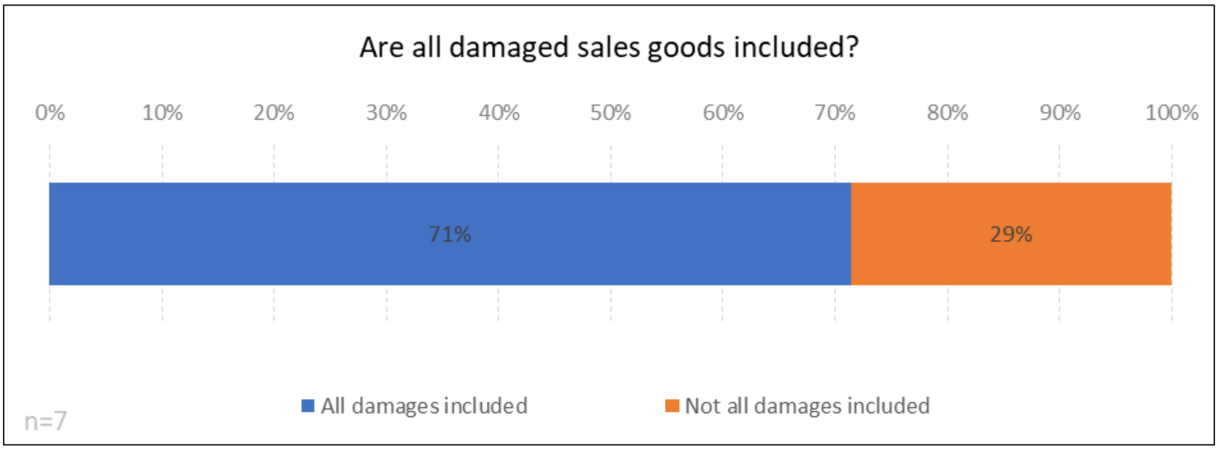



*Figure 250: Percentages of cases in which all damages were included in the value of question 19 or not, Netherlands (questionnaire part 2 commercial, question 28).*

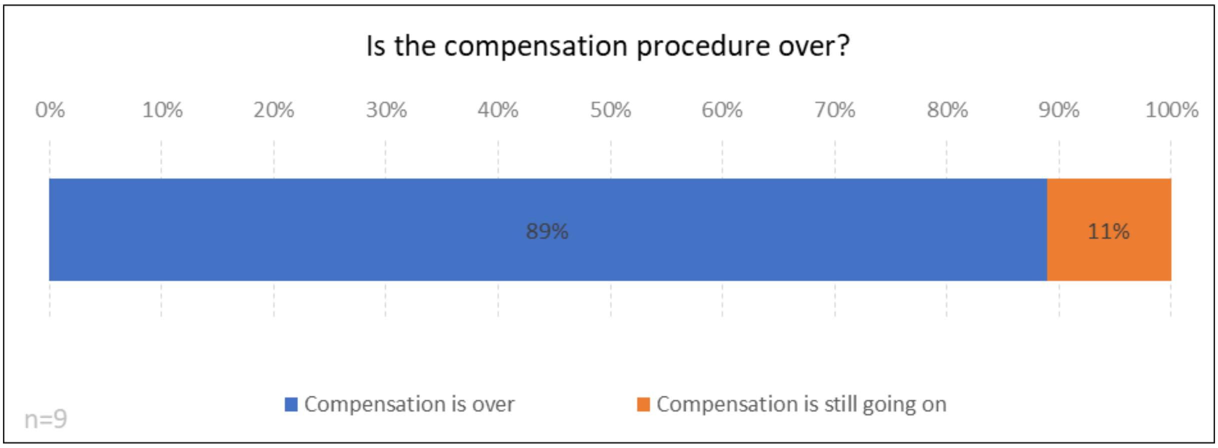



*Figure 251: Percentage of stages of completeness of the business of the participants, Netherlands (questionnaire part 2 commercial, question 29).*

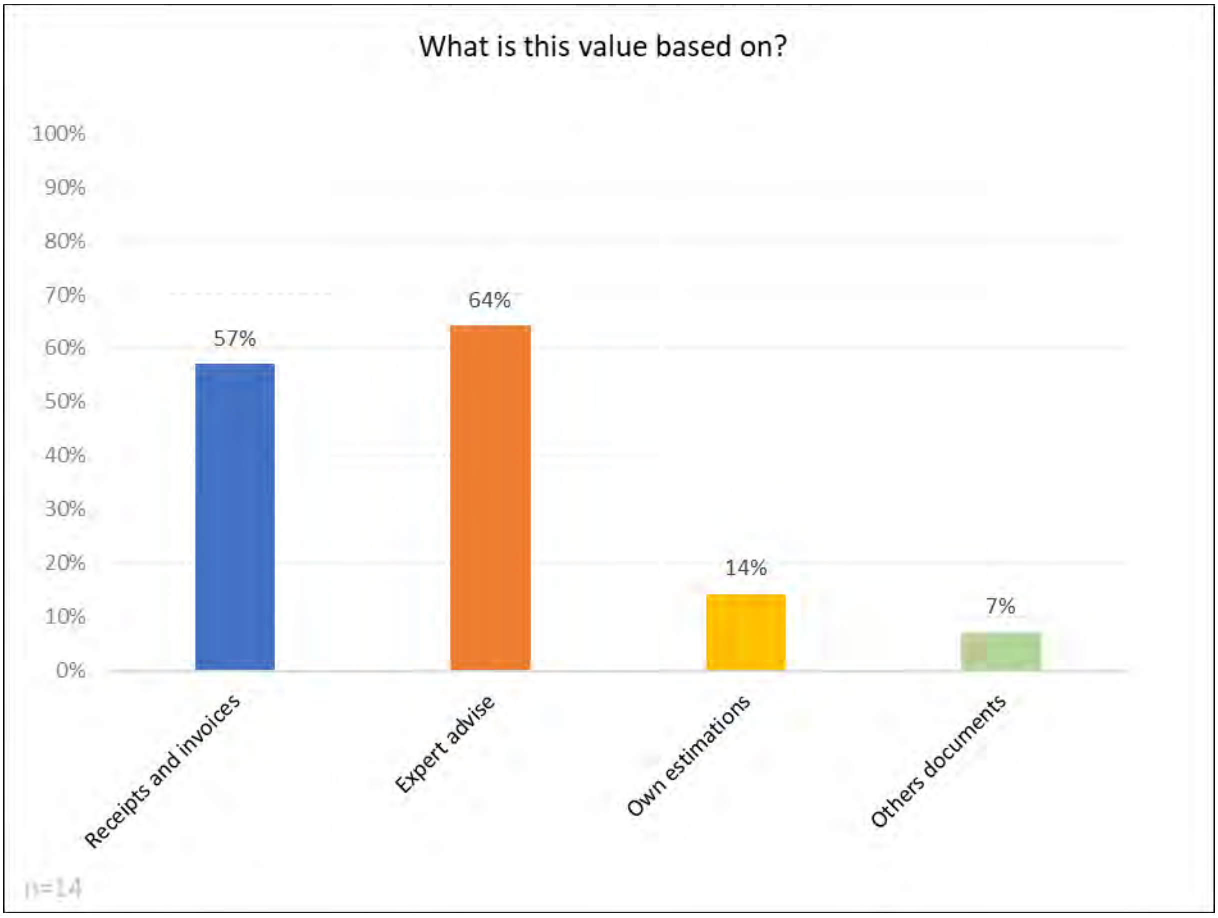



*Figure 252: Percentages of the base of the values from question 30, Netherlands (questionnaire part 2 commercial, question 31).*

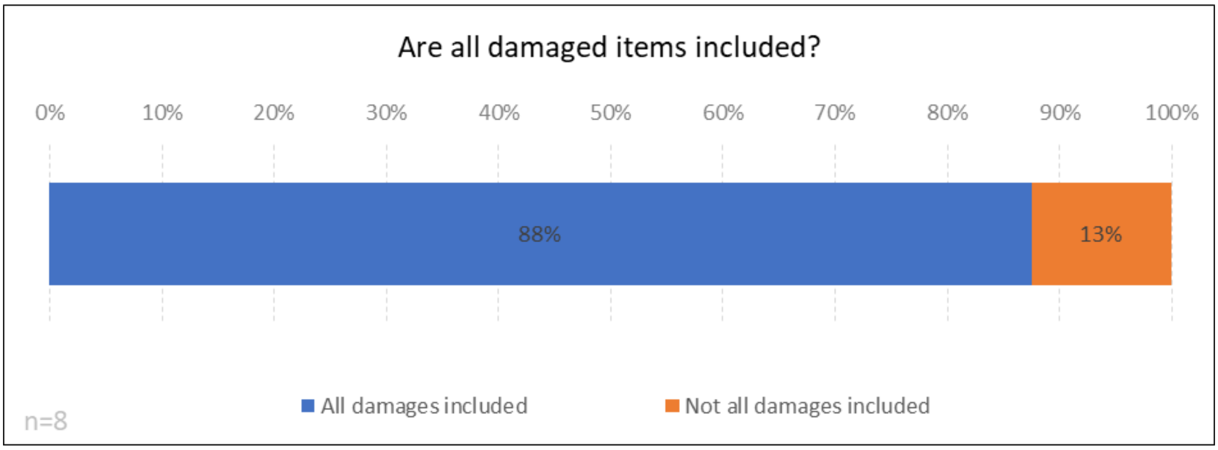



*Figure 253: Percentages of cases in which all damages were included in the value of question 30 or not, Netherlands (questionnaire part 2 commercial, question 32).*

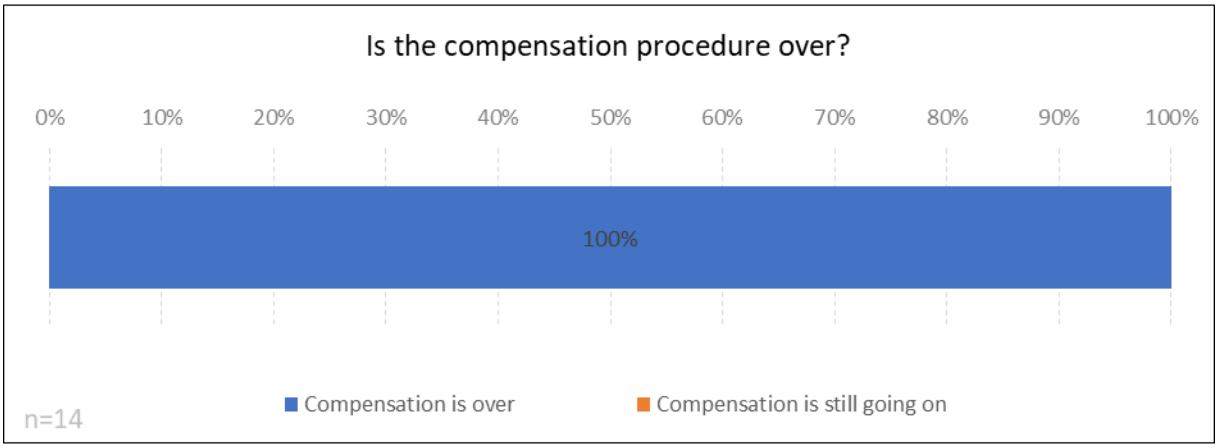



*Figure 254: Percentages of cases in which compensation procedure is over, Netherlands (questionnaire part 2 commercial, question 33).*

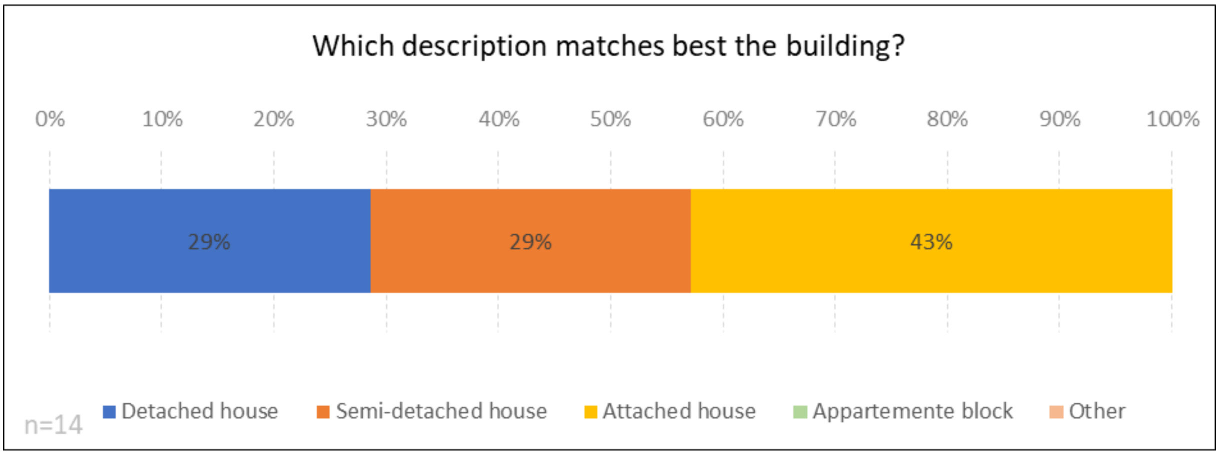



*Figure 255: Percentage of which types of buildings the participants work in, Netherlands (questionnaire part 2 commercial, question 36).*

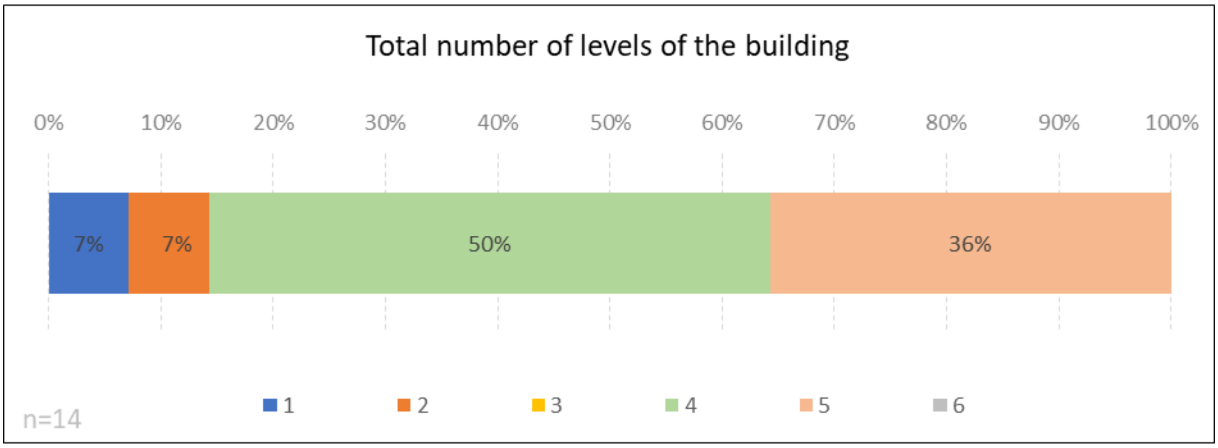



*Figure 256: Total number of levels of the buildings the participants work in, Netherlands (questionnaire part 2 commercial, question 38).*

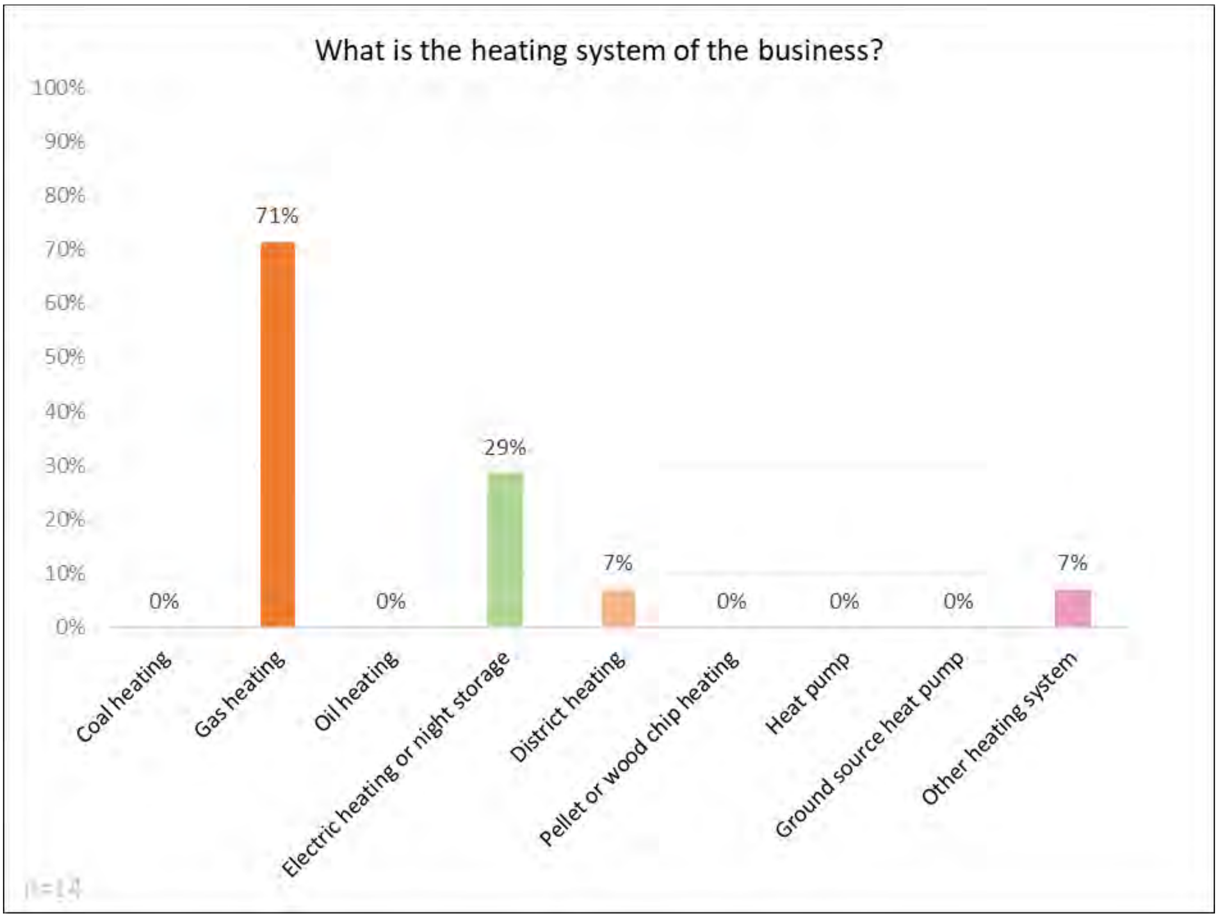



*Figure 257: Percentages of the heating systems of the participants, Netherlands (questionnaire part 2 commercial, question 43).*

*Table 38: Other heating system than mentioned in question 43, Netherlands (questionnaire part2 commercial, question 44).*

| Abundance | Other reasons for not receiving financial help |
|---|---|
| 1 | Air conditioner |

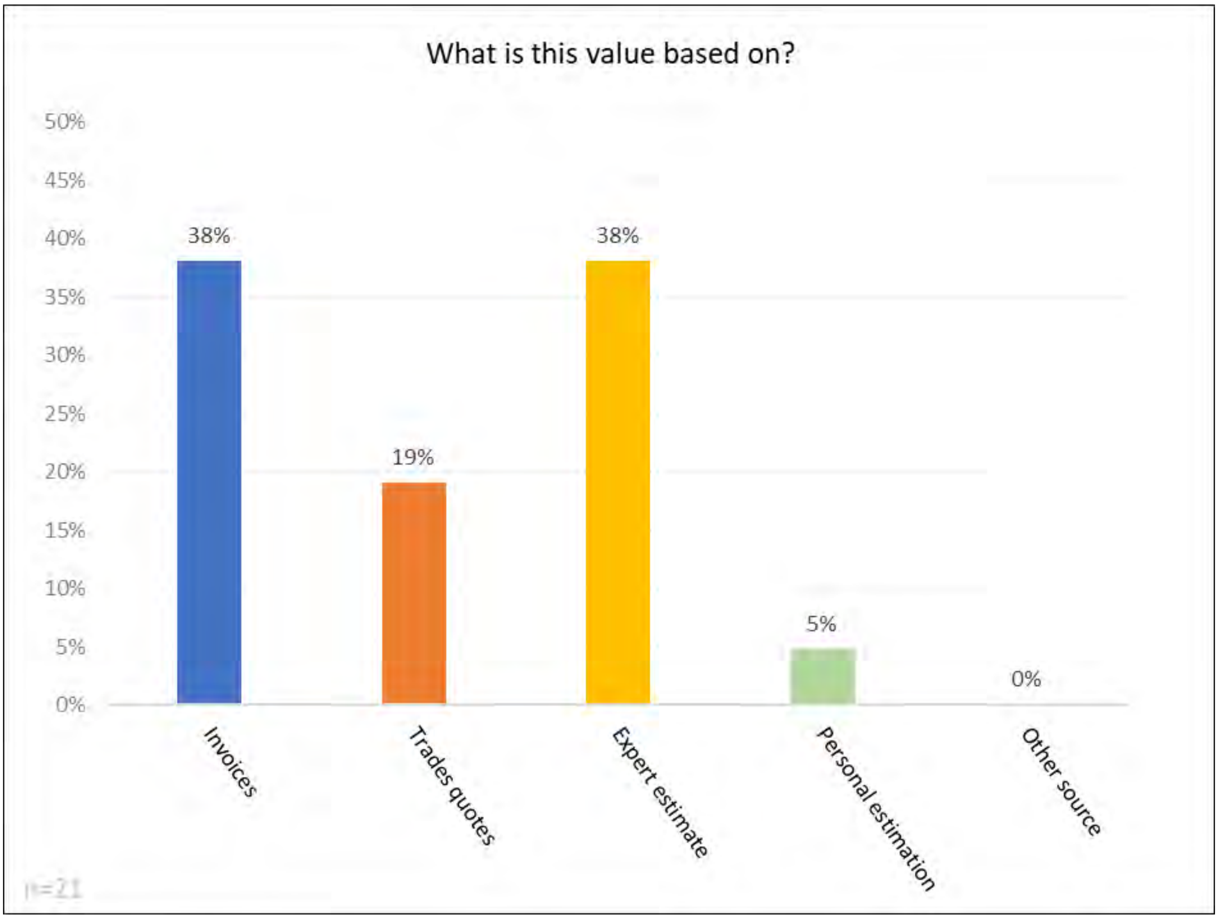



*Figure 258: Percentages of basis for the given costs in question 48, Netherlands (questionnaire part 2 commercial, question 49).*

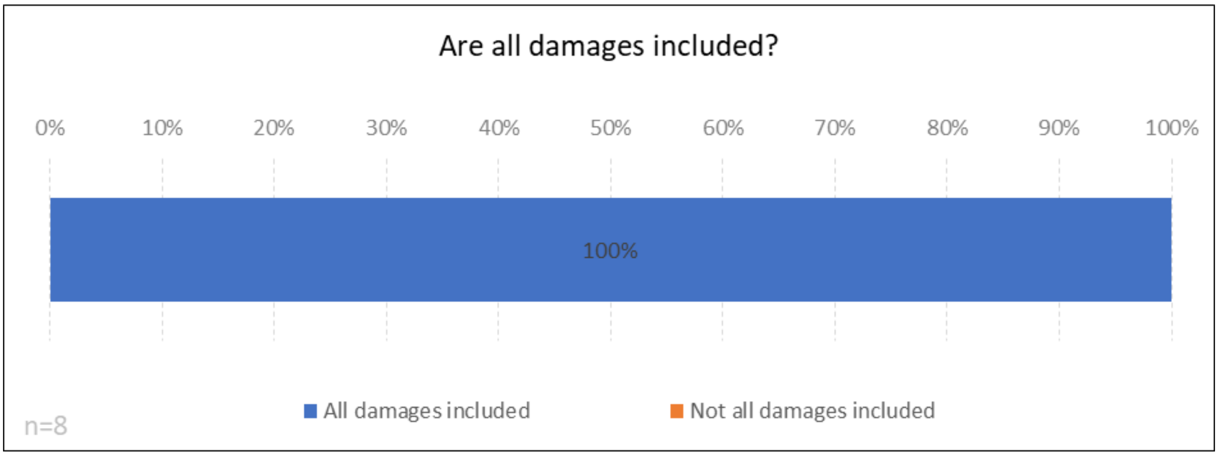



*Figure 259: Percentage of cost that included all damages, Netherlands (questionnaire part 2 commercial, question 51).*

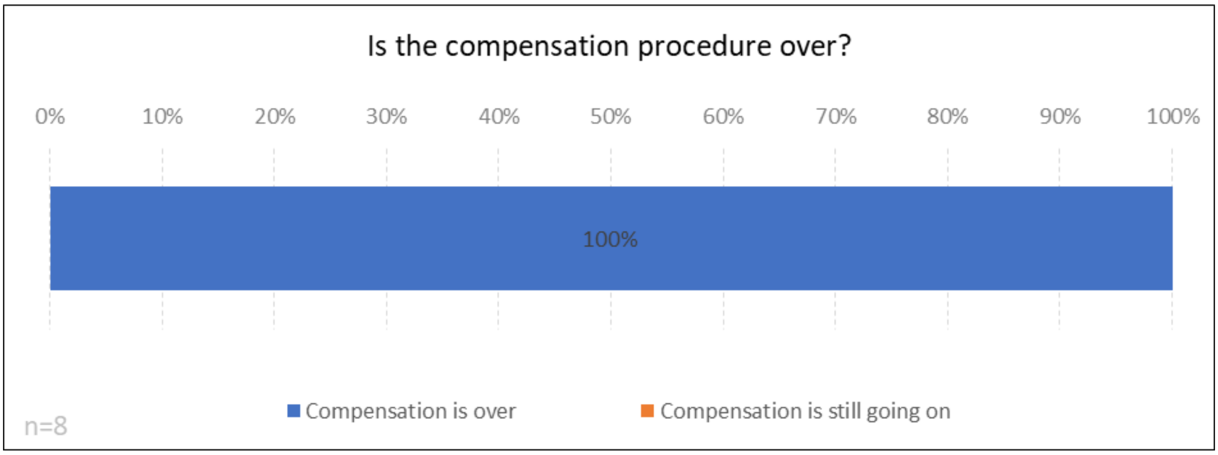



*Figure 260: Percentage if the compensation procedure is over, Netherlands (questionnaire part 2 commercial, question 52).*


*Figure 261: Box plot cleaning the building, a) reported cleaning hours to the insurance, b) compensation for cleaning from insurance, Netherlands (questionnaire part 2 commercial, question 54-55).*

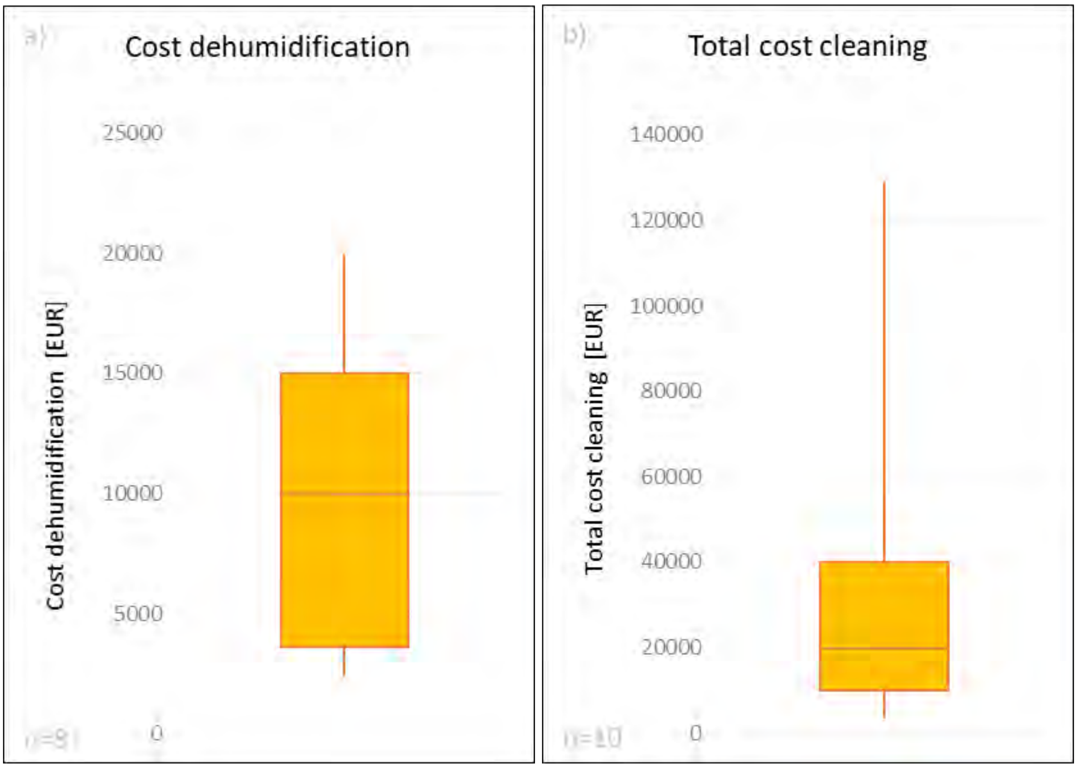



*Figure 262: Box plot representing cleaning costs, a) cost of dehumidification, b) total coasts to the cleaning of the building, Netherlands (questionnaire part 2 commercial, question 56 and 58).*

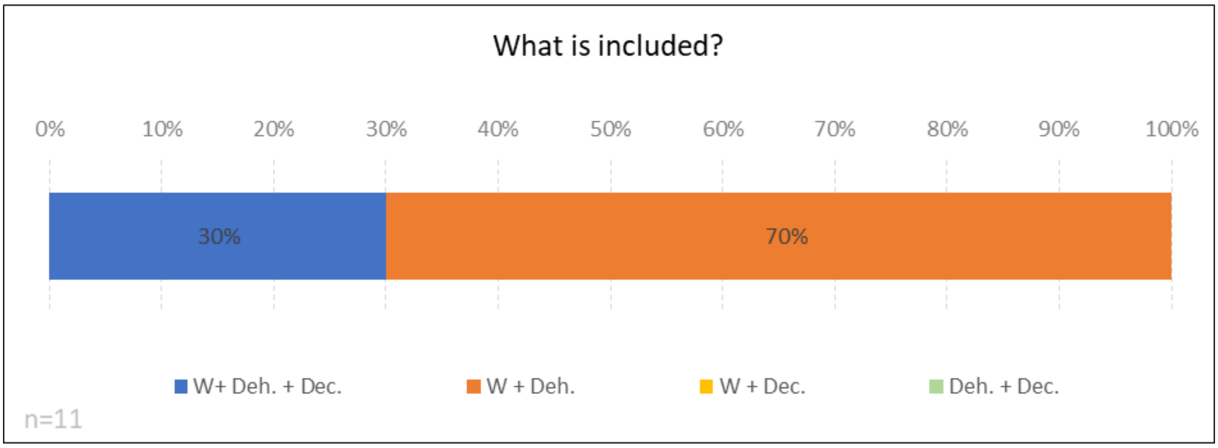



*Figure 263: Box plot of the total costs the participants had for buying or renting equipment for dehumidification, Netherlands (questionnaire part 2 commercial, question 59).*

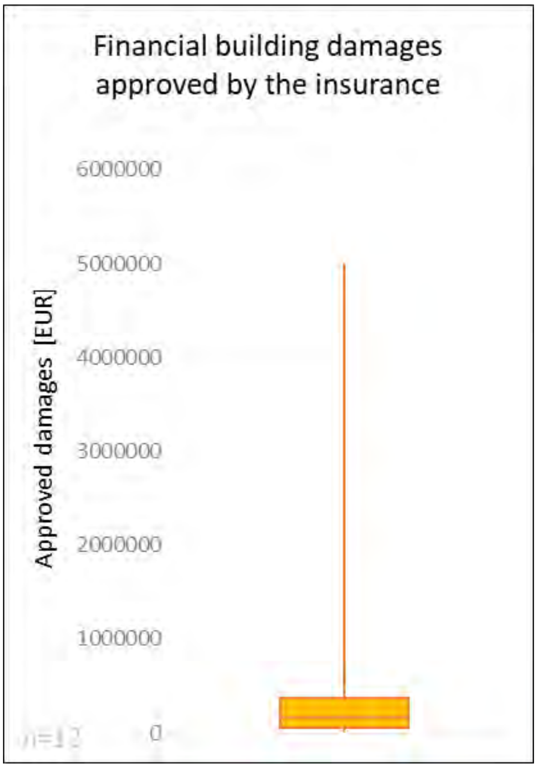



*Figure 264: Box plot of the approved amount of damage to or in the building by the insurance company, Netherlands (questionnaire part 2 commercial, question 60).*

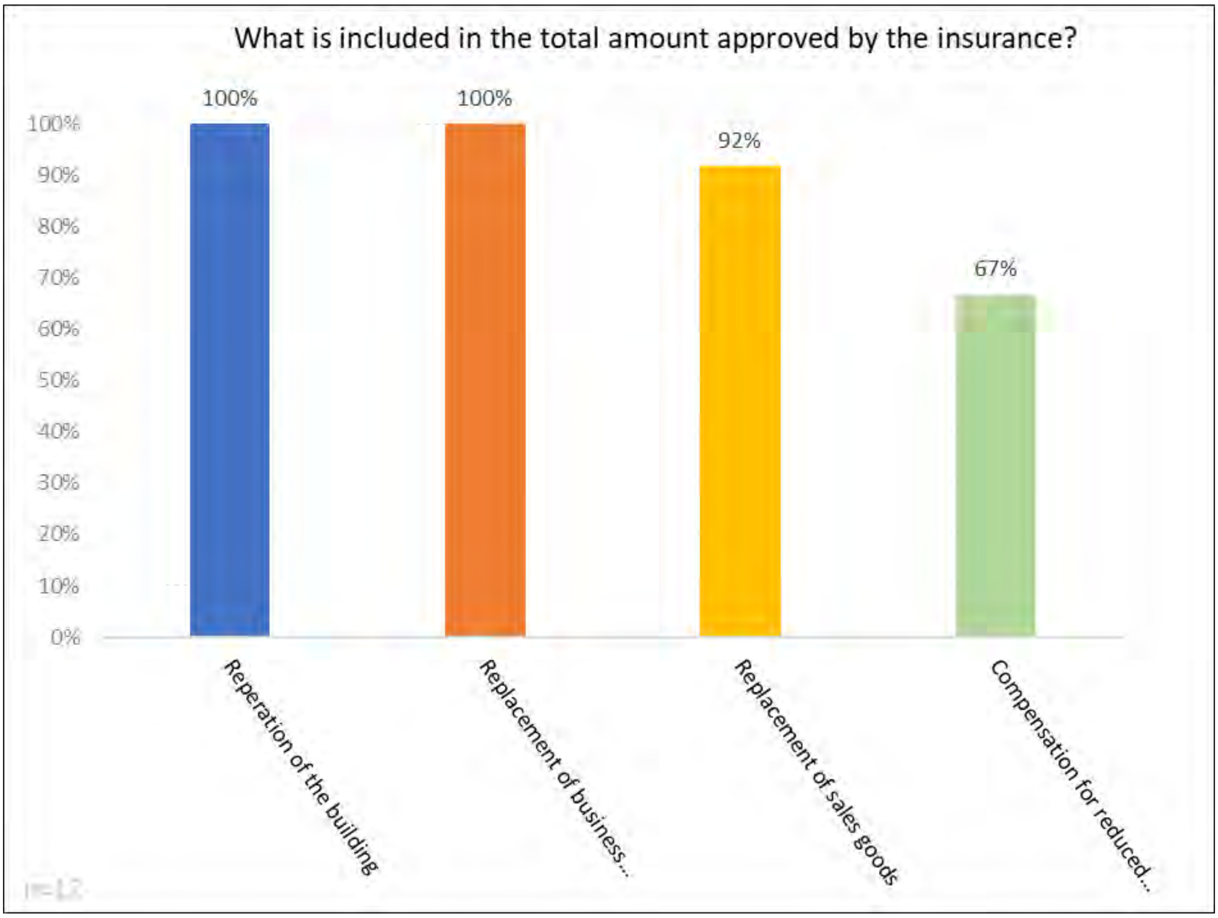



*Figure 265: Percentages of included costs in the total amount by the insurance, Netherlands (questionnaire part 2 commercial, question 61).*

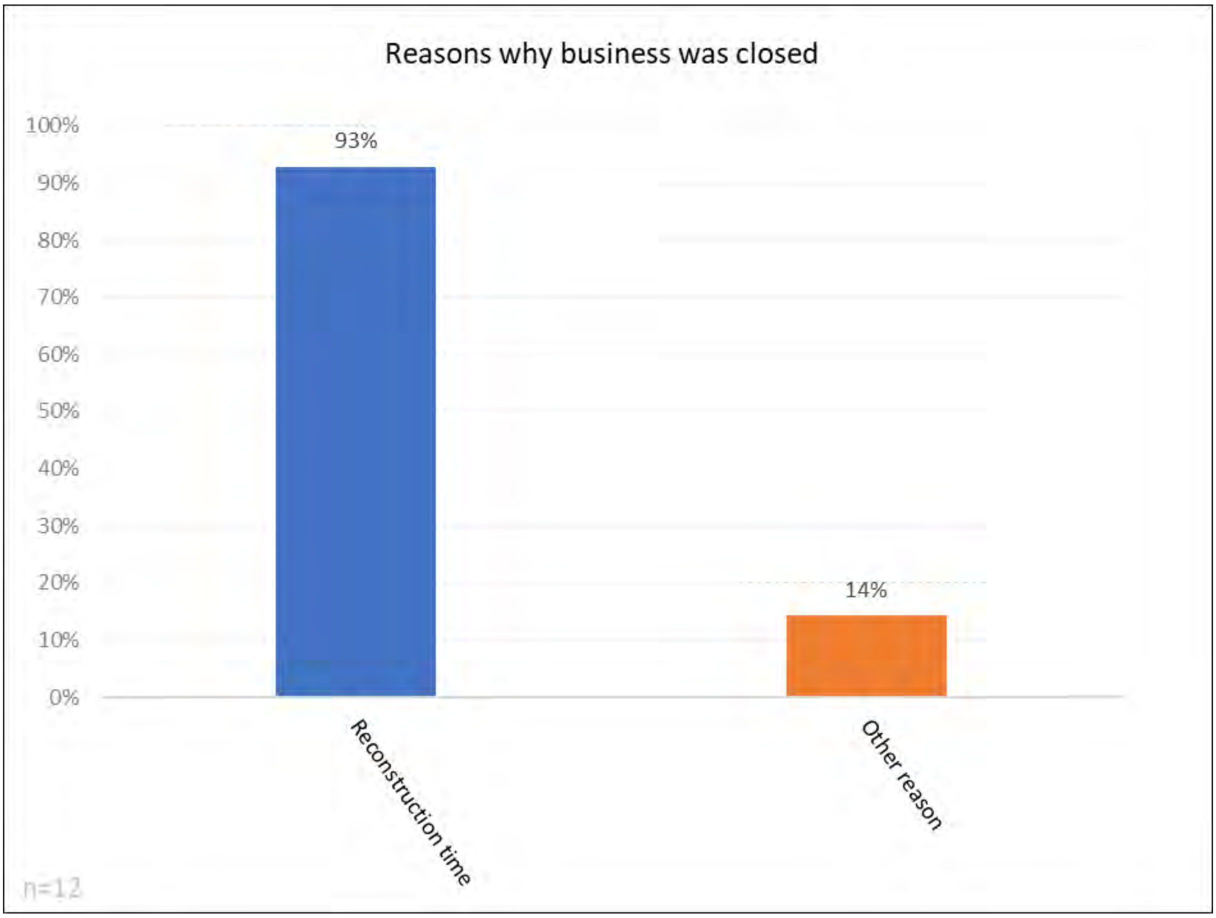



*Figure 266: Percentages of reasons, why businesses had to close, Netherlands (questionnaire part 2 commercial, question 64).*

*Table 39: Other reasons for business closure than mentioned in question 66, Netherlands (questionnaire part2 commercial, question 65).*

| Abundance | Other reasons for not receiving financial help |
|---|---|
| 1 | Sale of company |
| 1 | Covid-19 lockdown |

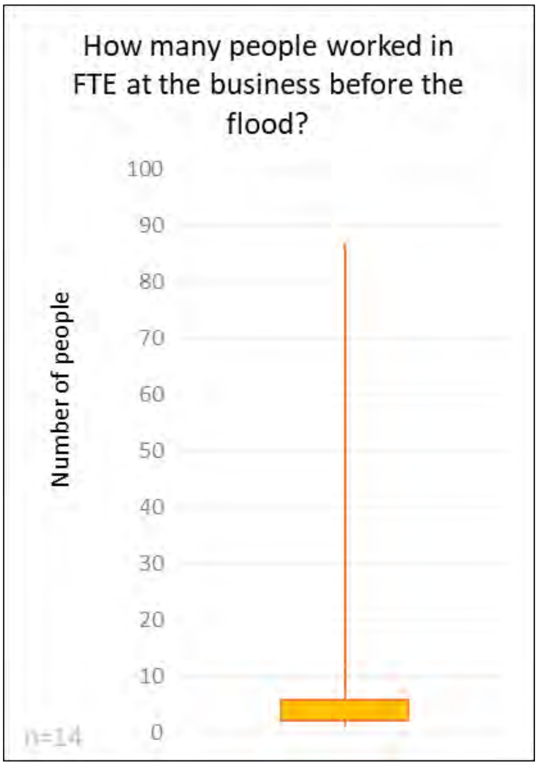



*Figure 267: Box plot of number of people worked at the business before the flood in Full Time Equivalent (FTE), Netherlands (questionnaire part 2 commercial, question 66).*

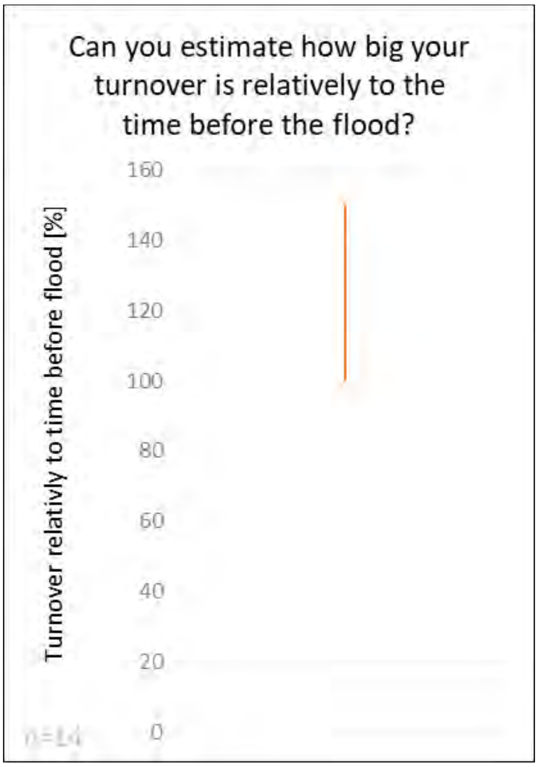



*Figure 268: Box plot of the turnover relatively to the time before the flood, Netherlands (Minimum, first quartile, median and third quartile are 100%) (questionnaire part 2 commercial, question 68).*

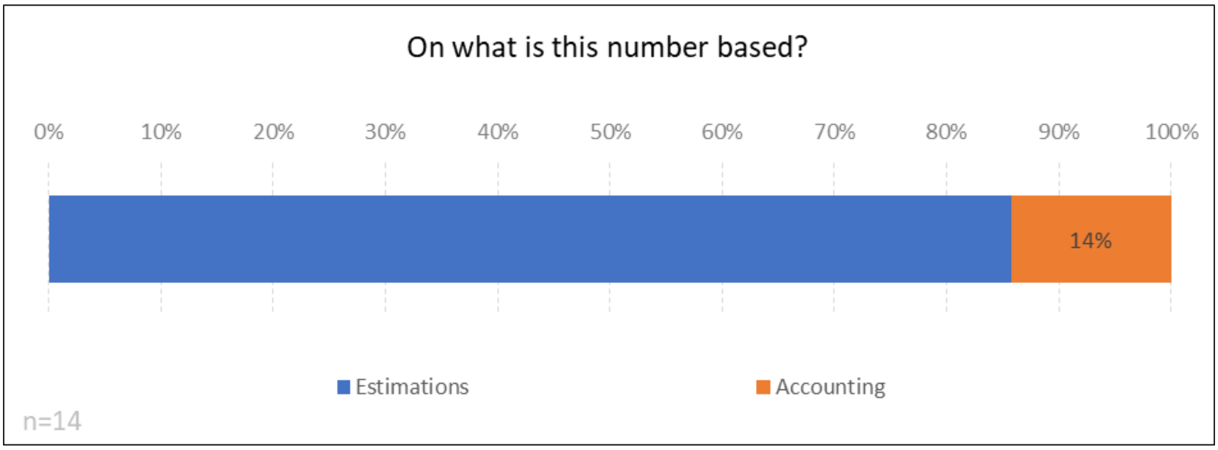



*Figure 269: Percentage of validation based on of question 70, Netherlands (questionnaire part 2 commercial, question 69).*

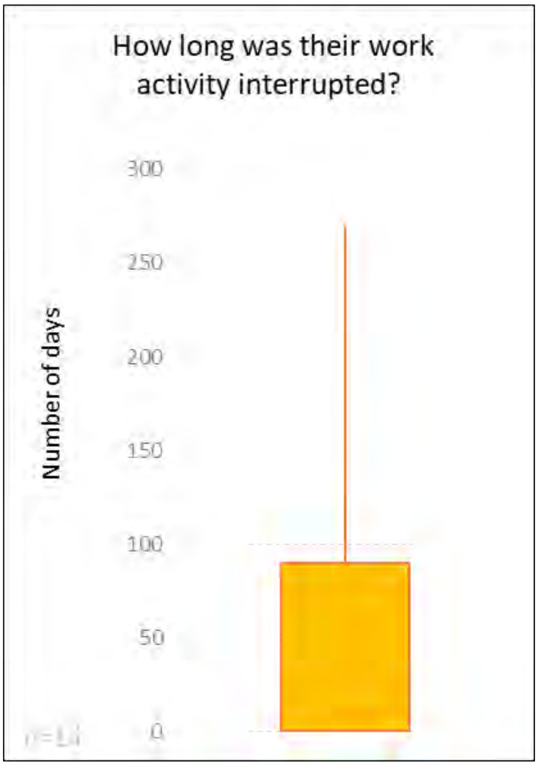



*Figure 270: Box plot of number of days the work was interrupted, Netherlands (questionnaire part 2 commercial, question 73).*

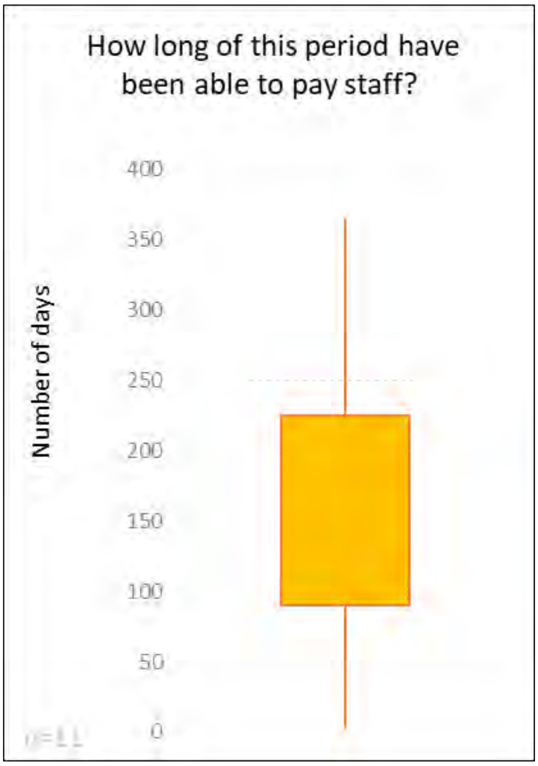



*Figure 271: Box plot of days, period businesses were able to pay staff, Netherlands (questionnaire part 2 commercial, question 74).*

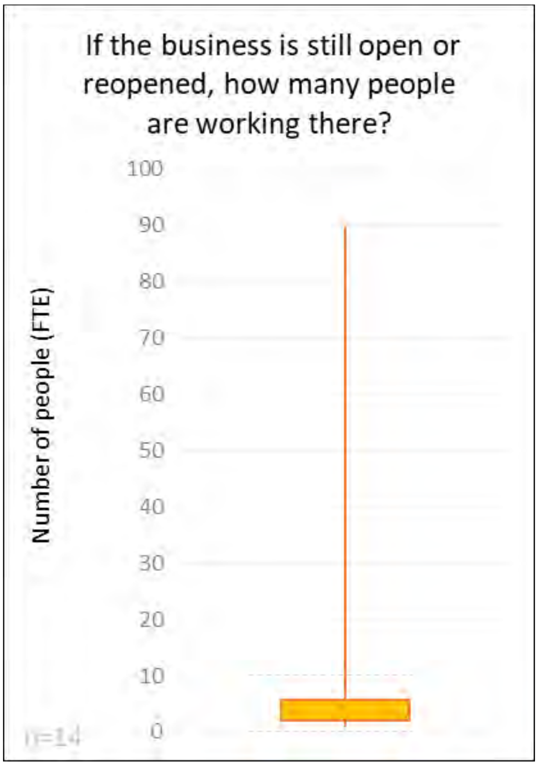



*Figure 272: Box plot of number of people working at the business at the time if the interview, Netherlands (questionnaire part 2 commercial, question 76).*

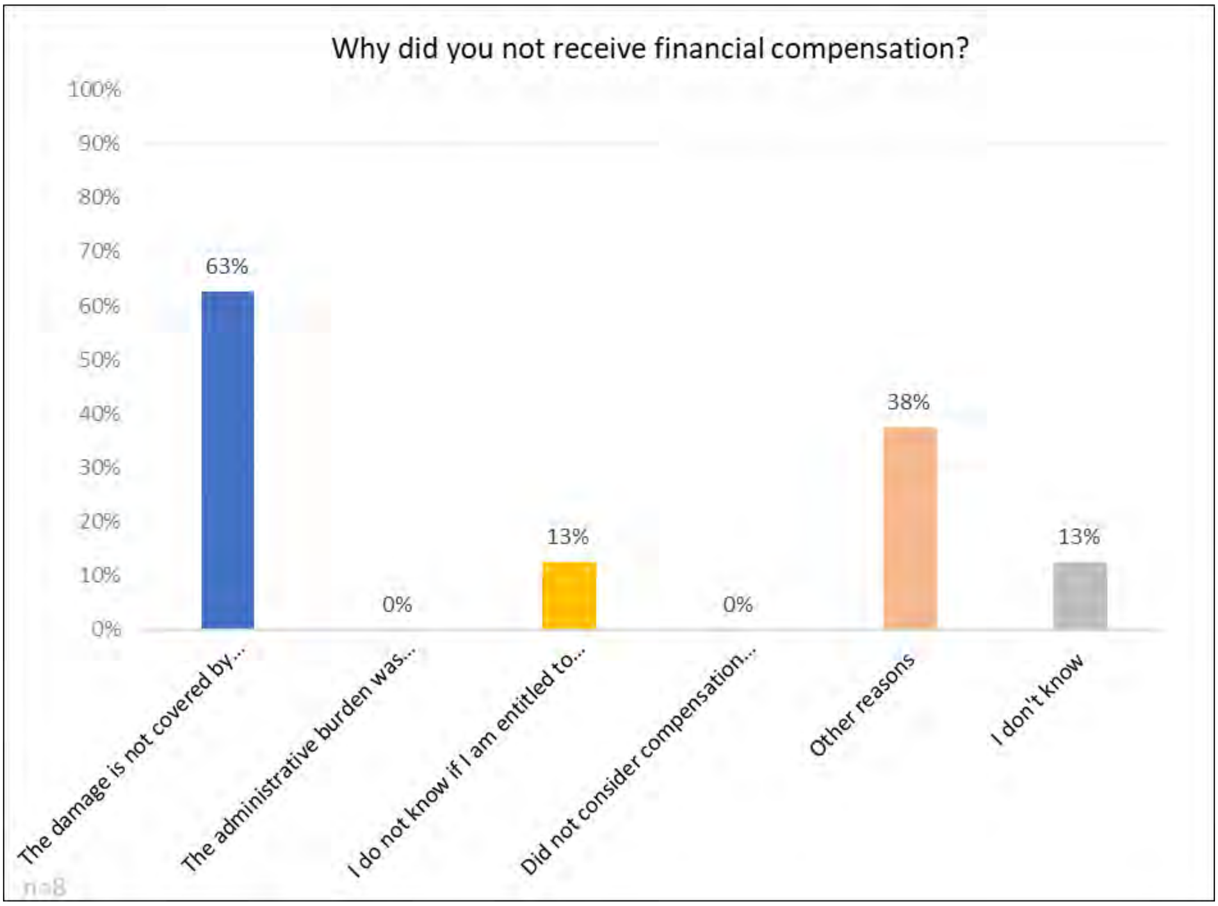



*Figure 273: Percentages of reasons for not receiving financial compensation, Netherlands (questionnaire part 2 commercial, question 78).*

*Table 40: Other reasons for not receiving financial help than mentioned in question 78, Netherlands (questionnaire part2 commercial, question 79).*

| Abundance | Other reasons for not receiving financial help |
|---|---|
| 1 | Bad estimation of profit loss |
| 1 | revenue compensation to low and pay back later |
| 1 | Takeover company after flood disaster, and then financed the biggest part myself |

*Table 41: Answers to the question which needs people still have, that have not yet been addressed, Netherlands (questionnaire part 2 commercial, question 80).*

| Number | Which needs do you still have that have not yet been addressed? |
|---|---|
| 1 | Nothing |
| 2 | Better communication from the government |
| 3 | Guidance and communication |

*Table 42: Answers to the question, what could have been done better in terms of information/support from government/own capabilities Netherlands (questionnaire part 2 commercial, question 81).*

| Number | What could have been done better in terms of information/support from government/own capabilities? |
|---|---|
| 1 | Amount of water was unexpected by everyone |
| 2 | Better information about consequences of donations |
| 3 | Turnover compensation, permanent. |
| 4 | Better warnings |
| 5 | Communication |
| 6 | Earlier warnings |
| 7 | All, no help |
| 8 | Better communication regarding the weather forecast, renovation of the Geul has to start hopefully |
| 9 | Guidance, transparency, and communication |
| 10 | Warnings |

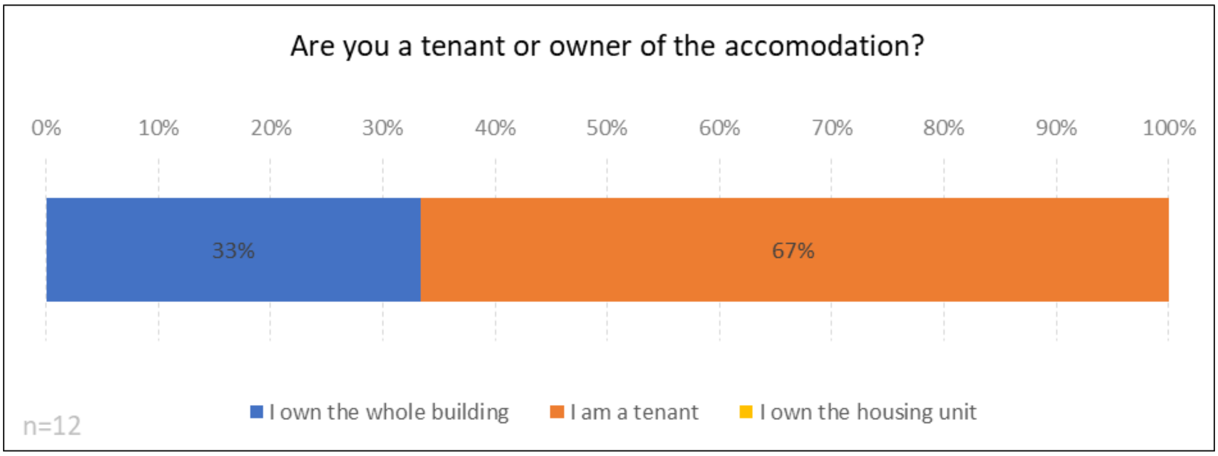



*Figure 274: Percentages of the participants who are owners or tenants of their home, Netherlands (questionnaire part 2 commercial, question 93).*