
Master's Thesis – Integrated Water Resources Management

TH-Köln (University of Applied Sciences)

ITT – Institute for Technology and Resources Management in the Tropics and Subtropics

and

University College Cork (UCC)

CHANGE OF RISK PERCEPTION AND RISK COMMUNICATION IN COUNTY CORK, IRELAND AFTER FORMER HURRICANE OPHELIA (2017)

Ines Martina Könsgen

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Integrated Water Resources Management

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PRESENTS:

Ines Martina Könsgen

SUPERVISOR OF THESIS ITT:

Prof Dr Udo Nehren

SUPERVISOR IN UNIVERSITY COLLEGE CORK:

Dr Kieran Hickey

DATE OF SUBMISSION

29.11.2022

presented by

Ines Martina Könsgen

Student no.: 11147953

Email: ines.koensgen@gmx.de

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Abstract

Due to its location at the south-west coast of Ireland County (Co.) Cork is frequently affected by post tropical cyclones (PTCs). There have been several records of these post hurricanes in the past with the last severe PTC being Hurricane Ophelia in 2017. It caused severe disruption in the whole country, especially in Co. Cork with several thousand people without water, power and mobile service for up to 10 days and thousands of uprooted trees which blocked roads. PTCs, like Ophelia, will become more frequent under climate change conditions due to warmer sea surface temperatures and decreased vertical wind shear. Hence, hurricanes can reach northern latitudes more easily and have a higher chance of making landfall in Co. Cork.

This thesis assesses the risk perception towards natural hazards (NHs) and the perception of the risk communication of hurricane Ophelia by the citizens of Co. Cork and suggests improvements in communication based on the people's perception. This was achieved by conducting a standardised survey to analyse the perception. The risk communication chain, its content and media involved were evaluated with interviews with professionals involved in risk management in Ireland. Improvement suggestions were extracted of the survey and the expert interviews as well and have been ranked by the participating experts according to their importance.

The people of Co. Cork are not overly concerned about being affected by NHs. The three hazards they feel threatened by most, after Ophelia hit the country, are storms, river floodings and hurricanes. Before Ophelia made landfall, they only ranked hurricanes in the 8th place (out of 8). Ergo, after experiencing Ophelia people are much more aware of hurricane risk in Ireland. People were very satisfied with the information they received during Ophelia. The improvements they wished for are: 1) information on how to deal with and how to prepare for impacts of the storm, 2) the impacts that can be expected locally and 3) information where to go to in case of severe impact to property. These are mostly in line with the improvements the experts ranked as most important for Cork. Experts voted the suggestion to include information on behavioural advice into risk communication before the NH hits and advice on how to organise for impacts afterwards as their number one priority. Their second rank is to have education and training for the citizens in Cork. On third place they voted for a change to impact forecasting. Even there are no central buildings or shelters available in Co. Cork, this improvement suggestion was only voted on rank 13 by the experts (out of 14). Having a participatory approach in risk communication can overcome the discrepancies between the wishes of the population and the ones of the experts and would lead to a better understanding of all stakeholders involved in risk communication and can reduce vulnerability of the people in Co. Cork to the impacts of NHs. The implementation of these activities would be in line with best practice examples and would support the guidelines of the Irish Framework for Major Emergency Management.

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List of Abbreviations

AGS	An Garda Síochána
App	Online Applications
BK	Borda-Kendall method
CCA	Climate Change Adaptation
CD	Civil Defence
CMT	Crisis Management Team
Co.	County
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
EMP	Emergency Management Plan
EMS	Emergency Management Structure
ESB	Electricity Supply Board
ESBN	ESB Networks
ET	Extratropical Transition
ETC	Extratropical Cyclone
FEMA	Federal Emergency Management Agency (USA)
FMEM	Framework for Major Emergency Management
GTF	Government Task Force
H	Hurricane
HSE	Health Service Executive
HSE	Health Service Executive
ITCZ	Intertropical Convergence Zone
JDM	Judgement and decision-making
LA	Local Authority
LCC	Local Coordination Centre
LCG	Local Co-ordination Group

MCA	Multi-Criteria Analysis
MH	Major hurricane
MM	Mental Models
NDFEM	National Directorate for Fire and Emergency Services
NECC	National Emergency Co-ordination Centre
NECG	National Emergency Co-ordination Group
NH	Natural Hazard
NHC	National Hurricane Center
OEP	Office of Emergency Planning
p.c.	Personal communication
PRA	Principal Response Agency
PTC	Post-tropical Cyclone
RCG	Regional Co-ordination Group
RCP	Representative Concentration Pathway
RTÉ	Raidió Teilifís Éireann
SM	Social Media
SST	Sea Surface Temperature
SWAT	Severe Weather Assessment Team
TC	Tropical Cyclone
TETRA	Terrestrial Trunked Radio
UCC	University College Cork
UK	United Kingdom
WWTP	Wastewater Treatment Plant

1. Introduction

Post-tropical cyclones (PTCs) make landfall in Europe regularly. Especially Ireland is hit by these remnants of hurricanes frequently which cause damage due to their high winds and rainfall. This location has the highest density of PTC effects over land in Europe, with an average of one or more PTC impacts annually (Sainsbury et al., 2020). The two most severe examples affecting Ireland were Hurricane Debby in 1961 with record winds and post-Hurricane Charly in 1986 with record rainfall (Hickey & Conolly-Johnston, 2012). In October 2017 former Hurricane Ophelia made landfall on the south coast of Ireland and caused three fatalities and damages to buildings, power lines, water supply services, trees, roads and communication networks (National Directorate for Fire and Emergency Management [NDFEM], 2019). Most severely affected has been County (Co.) Cork¹ where 90,000, 58,000 and 51,000 residents had no power, water and mobile service, respectively (Cork County Council, 2017).

These damages impacted the population of Cork. Hence citizens need to know how to deal with these impacts to become more resilient. Thus, communication towards the public about the risk of natural hazards (NHs) and especially the risks of PTCs is important to enable community resilience and spark autonomy in handling impacts that might occur through NHs. Risk communication is a vital part of disaster risk management (DRM) “because it shapes people’s perceptions of risk and influences their actions with respect to disaster preparedness and disaster response” (Shaw et al., 2013, p. 1). This is especially important as a large share of the population in Ireland “lacks an [...] awareness of [disaster] risks, adaptive measures and responses” (Medway et al., 2022, p. 7). However, to communicate accordingly, it must be understood how people perceive a hazard to tailor the communication strategy and its content (Fischhoff et al., 1993). Hence, to develop and assess risk communication procedures and programmes, risk perception studies are essential. The effectiveness of communication depends on understanding the issues that the intended audience has (Renn, 2008).

The need for communication becomes even more crucial as NHs become more prominent due to climate change. They increase in frequency and intensity (United Nations Office for Disaster Risk Reduction [UNDRR], 2022a). These hazards pose a threat to people and can become a disaster if they affect the environment adversely (UNDRR, 2018). This increase in NHs also affects hurricanes. Due to warmer sea surface temperatures (SSTs) and decreased vertical wind shear, hurricanes can reach northern latitudes more easily and thus pose a higher threat of making landfall in European countries, especially Ireland and the United Kingdom (UK) (Baatsen et al., 2015; Haarsma et al., 2013; Liu et al., 2017; Michaelis & Lackmann, 2019). The

¹ County Cork will be called “Cork” in this work, while the City of Cork will be indicated with “Cork City”

associated high winds, storm surges and large amounts of rain represent a danger to the population living along the coast and the tracks of the hurricanes.

As a result, Ireland was chosen as the study site of this research, especially Cork county, as it has the longest share of the coastline of the country (Neilson & Costello, 1999). Further, more than 60% of the people in Cork live within 5 km off the coast (Central Statistics Office [CSO], 2016d) and Cork has the highest share of the population living within 100 m off the coast in all of Ireland (CSO, 2016a). Additionally, Cork is a big contributor to the country's GDP and has main economic and touristic importance for Ireland (Cork County Council, 2022). This economic importance is under threat if a severe storm or hurricane is approaching which is not unlikely due to its vicinity to the coastline. This makes it very prone to NHs, especially coastal storms, like hurricanes.

Even though the number of PTCs is rising in Europe and it is more likely that hurricanes undergo an extratropical transition (ET) and affect European countries, like Ireland, one must notice that hurricanes are no longer tracked by the National Hurricane Center (NHC) as soon as a hurricane underwent ET (Hart & Evans, 2001). This was the same for Hurricane Ophelia, even though it was the strongest most eastern North Atlantic hurricane ever recorded with a category 3 on the Saffir-Simpson Scale (Byrne & McDonnell, 2017; Hickey, 2017; Met Éireann, 2018b; NDFEM, 2019; Rantanen et al., 2020; Stewart, 2018). This fact makes it even more important to communicate about the threats of PTCs.

Despite its extraordinary characteristics, there is only little research conducted on Hurricane Ophelia and no research about the risk communication or the long-term impacts of Ophelia on the population of Ireland or Cork. There are mainly Hurricane reports from the NHC or Met Éireann or documents of the Irish government. There is almost no research by the scientific community done on this storm or its long-term impact on the people in Ireland. Only a study by Medway et al. (2022) assesses the risk perception of experts in terms of Climate Change Adaptation (CCA) and Disaster Risk Reduction (DRR) but without focus on Ophelia or hurricanes in general. Thus, this study tries to overcome this gap by assessing the risk perception towards NHs of the people in Cork and the risk communication that happened during Ophelia. Further, it should be analysed if the communication is in line with the risk perception towards hurricanes of the people living in Cork and improvement suggestions will be given if there are discrepancies between the population's perception and the communication.

1.1. Objectives of this Study

This research aims to understand the change in risk communication before and after Hurricane Ophelia and how people's perceptions of NH-risk changed. In the end, suggestions are to be made on how to improve risk communication, if necessary.

To achieve this overall objective four specific objectives were formulated:

1. Recognize the risk perception of NHs of the people affected by Ophelia and how they have perceived the risk communication.
2. Identify how hurricane risk is and was communicated in Cork before, during and after Ophelia.
3. Show, if there is a change in risk communication and if this communication strategy is in line with the population's perception of the risk communication and the population's risk perception of NHs.
4. Collect improvement suggestions and highlight improvement potential in risk communication, especially if a divergence between communication and perception exists.

The objectives will be assessed with a standardised survey to gain information on the risk perception of the people and with expert interviews to gain information on the risk communication chain and content and an expert ranking for improvement suggestions. A detailed connection of objectives and methods and how they build up to answer the overall objectives can be found in chapter 5, Figure 13.

1.2 Outline of the Thesis

In the beginning, the study area of County Cork is described. Afterwards, Chapter 3 focuses on the state of the art relevant to this thesis and supports the importance of this study. Chapter 3.1 starts with a description of hurricanes and explains what hurricanes are, how they generate and how they are categorised. Further, it lists hurricanes that affected Europe previously together with their impacts, followed by a description of the impact of climate change on hurricanes for their future occurrence in Europe. In Chapter 3.2 the focus lies on Hurricane Ophelia. Its generation, development and track are described, as well as its characteristics, like wind speed, pressure, and wave heights. It is followed by a detailed description of the impacts that Hurricane Ophelia had on Cork for different sectors. Chapter 3.3 illustrated the emergency management structure (EMS) for severe weather in Ireland which was as well applied during Ophelia. The next section describes the conceptual framework. The concepts of risk perception and risk communication are explained in Chapters 4.1 and 4.2 respectively. Best-practice examples of risk communication are elucidated in chapter 4.3. A detailed description of the methodology can be found in Chapter 5, here the preparation and use of the methods are described as well as the evaluation of the gained data. Afterwards, the results of the Survey (Objective 1) and the results of the Interviews (Objective 2) together with the results of the expert ranking (Objective 4) are displayed in Chapters 6 and 7. In Chapter 8 the results are discussed, and an answer is given to Objective 3 and the overall Objective. The Conclusion summarises all findings and gives an outlook for the future.

2. The Study Area – County Cork, Ireland

Cork County is located on the south coast of Ireland (Figure 1) and is part of the Province of Munster (The Editors of Encyclopaedia Britannica, 2021). The county has an area of 7500 km² and is the largest county in Ireland (Building City Dashboards, 2021). Cork has a Cfb climate after the Köppen and Geiger Classification, which is a warm temperate climate, fully humid with warm summers (Kottek et al., 2006). The county has a mean temperature of 9.8°C and a yearly precipitation of more than 1200 mm based on the information from Cork Airport weather station as shown in Figure 2. It has the ecoregion of a broadleaf forest and can be classified as a temperate broadleaf and mixed forest biome (Dinerstein et al., 2017).

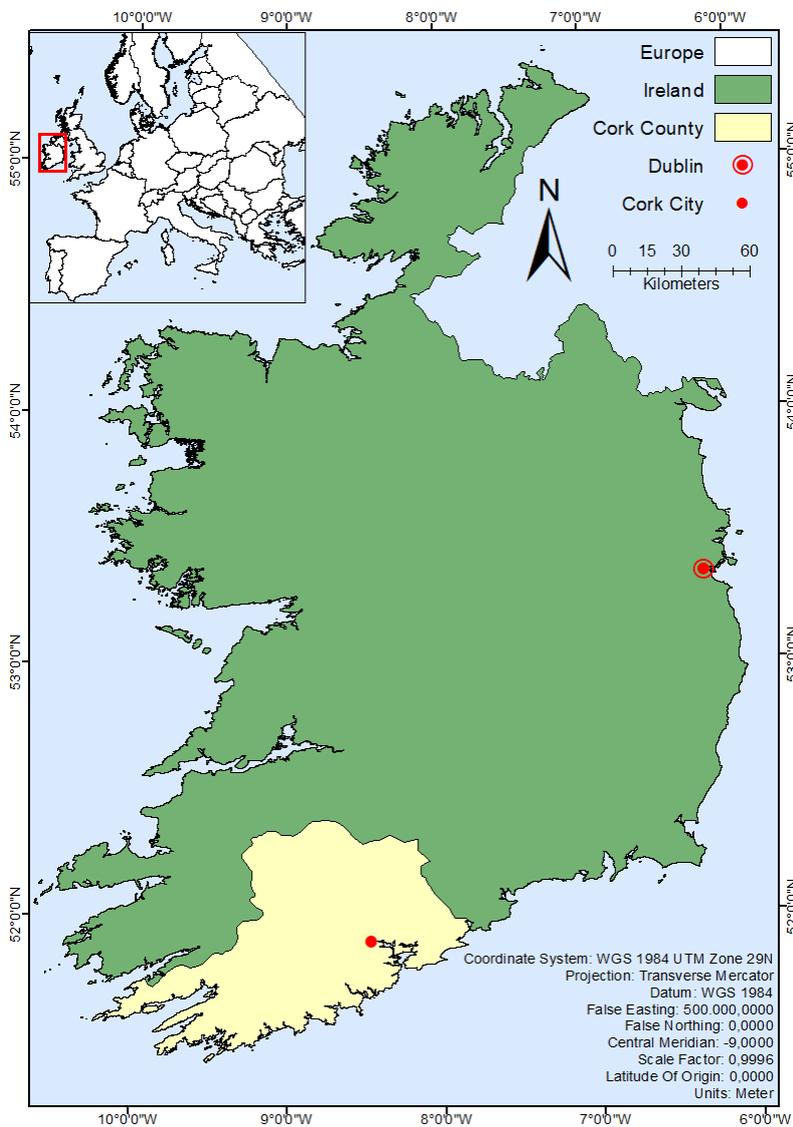


Figure 1: Location of Co. Cork in Ireland.

Map created by author. Data: Eurogeographics (2021), Geofabrik (2021), Hijmans et al. (2012)

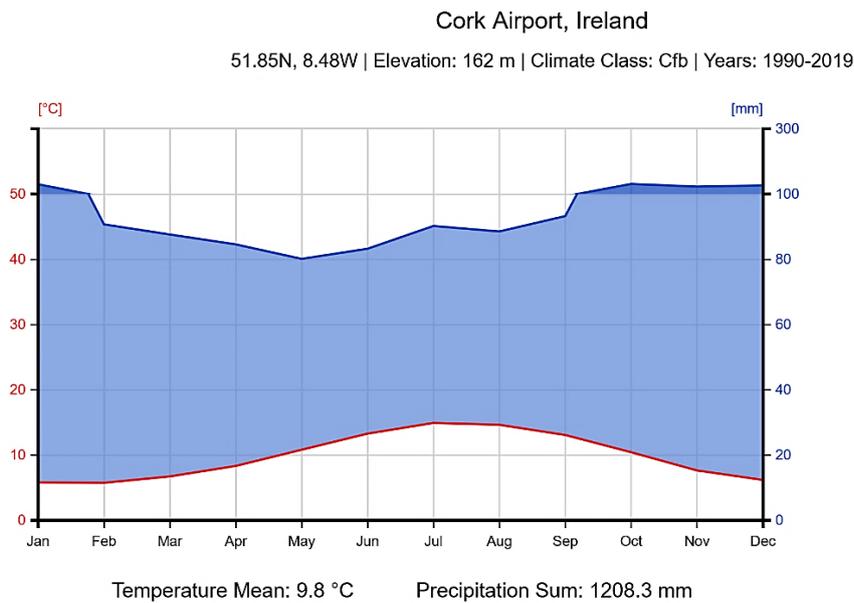


Figure 2: Climate chart of Cork airport
Source: Zepner et al. (2021)

Cork has 542,868 inhabitants (CSO, 2016c) of which 208,669 live in Cork City and its suburbs (CSO, 2018). While the population density in Cork City is 1,197.6 inhabitants/ km² for Cork City (CSO, 2016b), the population density of the whole county is only 72.4 inhabitants/ km². Most importantly Cork has 1,198.5 km of coastline, which is 15.9% of the whole Irish coast (Neilson & Costello, 1999). This makes the county prone to NHs from the sea, like storm surges, tidal floodings and storms, such as PTCs.

Moreover, Figure 3 shows that more than 60% of Cork's population lives within 5 km proximity off the coast and more than 30% within 1 km off the coast. More importantly, approximately 17,140 inhabitants live within 100 m off the coast. This is the highest proportion of inhabitants in all of Ireland (CSO, 2016a). Hence these people are under threat to be affected by the impacts that natural coastal hazards can cause on land.

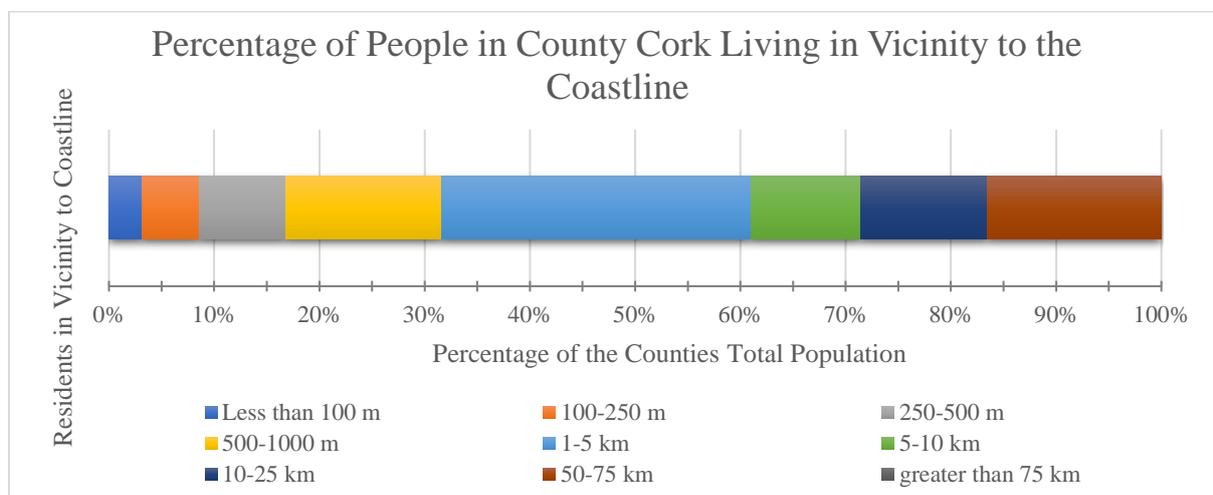


Figure 3: People in Cork living in vicinity to the coastline (in %).
Chart created by author. Data: CSO (2016d)

Additionally, Cork City is the main economic centre of the county and the second largest city in Ireland, after Dublin (The Editors of Encyclopaedia Britannica, 2021). Hence, it is not surprising that Cork City contributes to 19% of the country's GDP (Cork City Council, 2022) and Cork County had the 6th largest household median gross income in 2016 with a disposable income of €22,421 for 2019, which is more than the states average and the 4th highest of the country (Cork County Council, 2022). The main employment sectors in 2016 in the county were 1) professional services, 2) commerce and trade, 3) manufacturing industries, 4) agriculture, forestry, and fishing, 5) transport and communications and 6) public administrations. Further tourism is a large economic sector in Cork, with 11.76% of all domestic visitors and 10.69% of overseas visitors in 2017. This is the second-largest share of domestic tourists after Dublin and the third-largest share of overseas tourists after Dublin and Galway. Where domestic tourists resulted in revenue of €202 million and overseas visitors in revenue of €631 million (the second largest revenue of international tourism in Ireland) (Cork County Council, 2022).

3. State of the Art

The content of this chapter is based on a literature review in Scopus, Google Scholar, Academia.edu and on reviews of university libraries of the University of Applied Science Cologne and the searching portal bonnus of the University of Bonn. Of the selected literature the abstracts were screened and non-relevant literature for each topic was excluded.

3.1. Hurricanes

In this chapter, an overview of hurricanes is given. To understand the difference between average storms and hurricanes a description of their characteristics, their generation and transitions to the mid-latitudes will be given. Further, the section focusses on the hurricanes that already affected Europe in the past, to show that risk communication about hurricanes is a necessary measure for DRM, especially as in the end, the influence of climate change on the occurrence of hurricanes in Europe is illustrated.

3.1.1. Characteristics of a Hurricane, its Generation and Transition

Hurricanes are tropical cyclones (TCs) that occur in the Atlantic Ocean. These TCs are called Typhoons in the Pacific Ocean and Cyclones in the Indian Ocean. The tropical regions of the southern hemisphere are not frequently affected by TCs due to cooler ocean currents, while the northern hemisphere is frequently affected by TCs (Hempel & Hebold, 2012).

Hurricanes are very powerful storms that consist of several counterclockwise rotating (in the northern hemisphere) convection cells with an average diameter of 300-800 km that generate high winds of 119 km/h up to more than 300 km/h, are associated with precipitation amounts of 100-400 mm a day, high storm surges, have a warm core and low central air pressure (Klose

& Klose, 2015; Malberg, 2007). They can be categorised with the help of the Saffir Simpson Scale into five hurricane strengths, as shown in Table 1. Where storms categories 3 to 5 are also called “major hurricanes” (MH) and storms of categories 1 and 2 are described as “hurricanes” (H) only (Klose & Klose, 2015).

Table 1: Saffir-Simpson hurricane wind scale

Category	Wind (km/h)	Central Air Pressure (hPa)	Storm Surge (m)
Tropical Depression	46 – 62	/	/
Tropical Storm	63 – 118	/	/
Category 1	119 – 153	> 980	1.2 – 1.6
Category 2	154 – 177	965 – 979	1.7 – 2.5
Category 3	178 – 208	945 – 964	2.6 – 3.7
Category 4	209 – 251	920 – 944	3.8 – 5.4
Category 5	> 251	< 920	> 5.5

Information from Deutscher Wetter Dienst (2022a)

How a TC generates is described below, this is also applicable to all systems mentioned above. However, all the facts below are describing the characteristics of a northern hemisphere TC generation.

Hurricanes generate in the tropics between 5-35° northern latitude over the ocean between late summer (beginning usually in July) to autumn (with the end in October) where the SST is between 26°C and 27°C or higher up to a depth of at least 60 m (Cornell et al., 2022). They can also generate over cooler waters if there is a large temperature gradient between the troposphere and the surface temperatures (Klose & Klose, 2015). This temperature gradient was also the catalyst for Ophelia’s strengthening (Stewart, 2018). Additionally, the intertropical convergence zone (ITCZ) is moving northwards during this time. In the area of the ITCZ easterly waves are developing which can strengthen into hurricanes under the right conditions (Malberg, 2007).

The warm SST is the source of hurricane strengthening. Hurricanes gain their power via latent heat release of water vapour that condensates in the mid and upper troposphere and thus releases the latent heat. As a result, the troposphere warms up and the pressure increases. Hence a divergent wind field is created that causes lateral mass outflow. Because of this, there is a pressure drop at the sea surface. A low-pressure field is created at ground level which is compensated by incoming air that again takes up water vapour that condensates in the upper troposphere. Thus, the hurricane intensifies. To equal the pressure gradient, warm air of the troposphere moves back down to the surface and creates a warm region with very calm winds and no clouds (Klose & Klose, 2015). This region is called the “eye” and has an average diameter of 10-30 km (Malberg, 2007) or 20-65 km (Klose & Klose, 2015). Additionally, there must be a low vertical wind shear because a strong wind shear hampers the generation of convection cells, of which

the hurricane consists (Klose & Klose, 2015). The hurricane's typical rotation is created through the Coriolis force. Due to that force, the hurricane turns counterclockwise. This is one of the reasons why hurricanes do not generate in equatorial regions because the Coriolis force is non-existent (zero) there. The Coriolis force triggers the lateral outflow of the air through the eye of the hurricane (Cornell et al., 2022).

Hurricanes move over the Atlantic Ocean with an average speed of 18.5-55.6 km/h (Klose & Klose, 2015). When they reach land, they weaken steadily due to the loss of latent heat release of water vapour and friction with land (Hempel & Hebold, 2012). However, if the remnants weaken but reach warm ocean waters again, they can regain strength. The typical track of a hurricane looks like a parabola which is open to the east as shown in Figure 4. In the beginning, the storm moves westward in the direction of the United States due to the easterly waves between 5-30° northern latitude (National Hurricane Center [NHC], 2021). The closer they move to 30° northern latitude, the more the system is influenced by the Bermuda highs or the Azores highs. These high-pressure systems steer the hurricane towards the north and northeast. The further the TC moves northwards, the closer it gets to the westerlies where it can undergo an ET and reach Europe (University of Rhode Island, 2020).

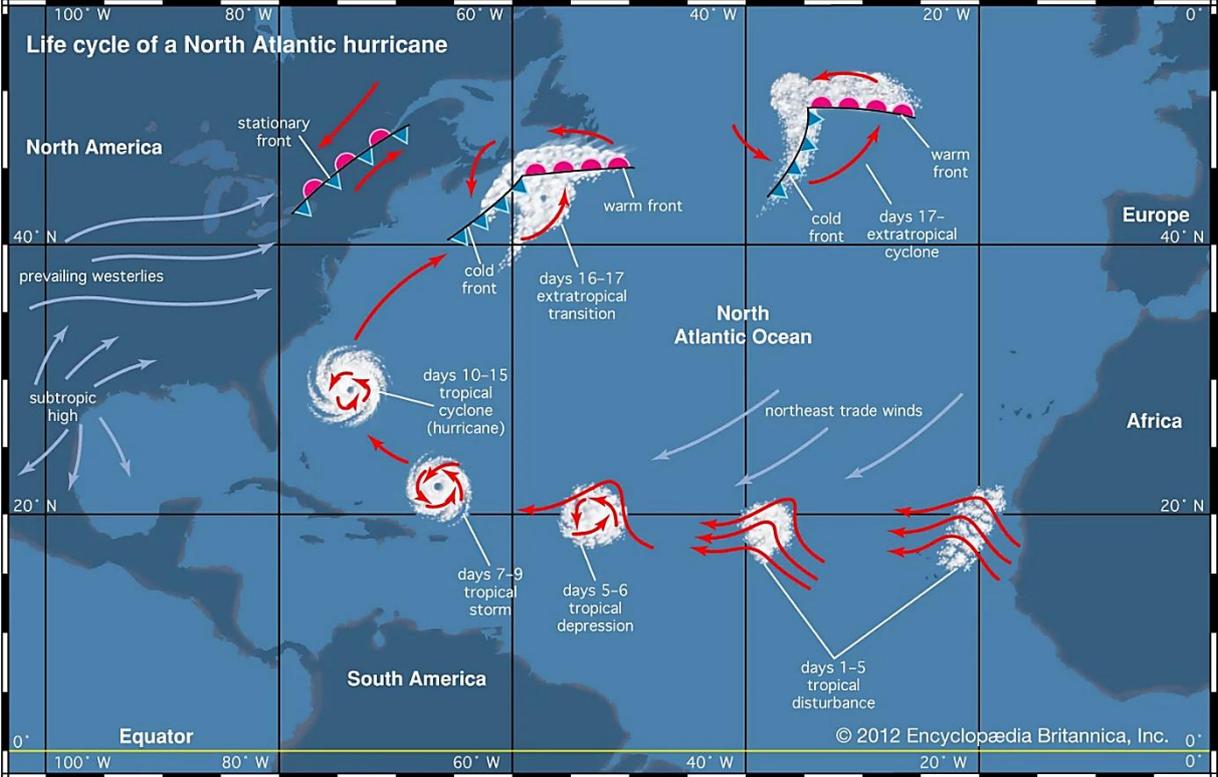


Figure 4: Example of a life cycle of a North Atlantic hurricane
 Source: Encyclopaedia Britannica (2012)

Regarding S. C. Jones et al. (2003) there is no overall accepted definition of ET however it can be described as the process where a TC moves from its tropical origins to areas outside of the tropics. During this process “a TC loses its tropical characteristics and becomes more

extratropical in nature.” (S. C. Jones et al., 2003, p. 1054). J. L. Evans and Hart (2003) and C. Evans et al. (2017) describe ET as a period, where the cyclone's tropical traits are replaced with characteristics common to extratropical cyclones (ETCs), such as a cold core and fronts.

While TCs are mainly driven by warm SST which result in latent heat release through moist convection, ETCs are driven by baroclinic processes² through north-south temperature and moisture gradients. Thus, the TC experiences baroclinic processes during its ET, before it might become a PTC (Rantanen et al., 2020). Hence, increased baroclinicity and vertical shear, meridional humidity gradients, lowered SST, or severe SST gradients are examples of possible alterations in the TCs environment while going through ET. However, during a transition, the TC can already decay and not complete its transformation. If the TC completes the transition, it can either weaken or it can become an extratropical system, also called PTC to symbolise its prior tropical characteristics (S. C. Jones et al., 2003). The possible developments are shown in more detail in Figure 5.

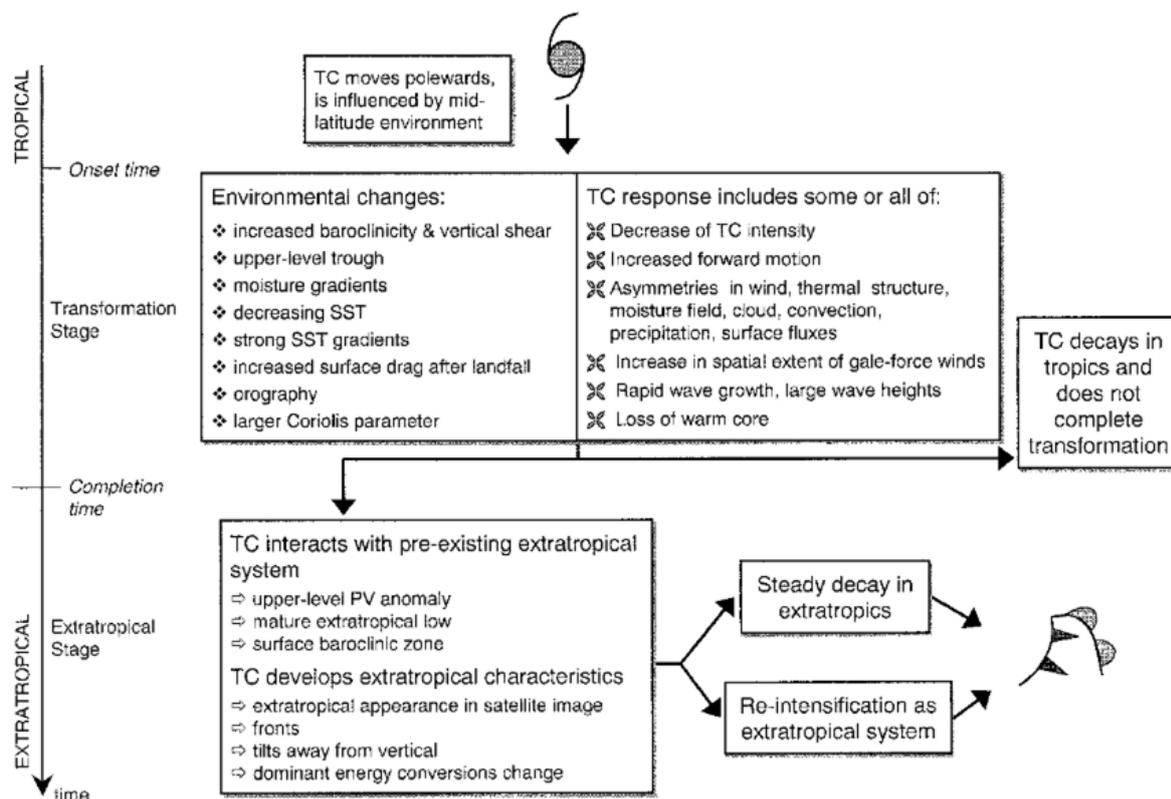


Figure 5: Characteristics and classifications of a TC during ET
 Source: S. C. Jones et al. (2003) based on information from J. L. Evans and Hart (2003).

If a TC re-intensifies after ET and becomes a PTC, it poses hazards such as gale-force winds, heavy rainfall, and large waves. Additionally, there can be inland flooding and wind-induced

² Baroclinicity describes the state that isobars and isotherms are not parallel to each other but intersect. Therefore, a pressure gradient exists. In baroclinically stratified air masses, the occurrence of laterally directed forces leads to the formation of flows also in the horizontal direction

wildfires. The maximum rainfall occurs left of the centre of the PTC in the northern hemisphere due to its asymmetric pattern (S. C. Jones et al., 2003).

The phenomenon of TCs undergoing ET is not unusual. In the following chapter examples of hurricanes that underwent ET and reached Europe are described together with their impacts on European countries. It will illustrate that hurricanes are not a rare phenomenon in Ireland and that awareness of hurricanes could be existent in among the population of Cork.

3.1.2. Hurricanes in Europe

As described previously, hurricanes that undergo ET pose a threat to European countries when these PTCs reach Europe with their strong winds and heavy precipitation. It is not unusual that ET occurs to hurricanes and Ophelia was not the first post-tropical hurricane that has hit Ireland and will not be the last one.

There is much evidence that hurricanes made landfall in European countries before Ophelia. Especially the remnants of post-Hurricane Charley in 1986 and Hurricane Debbie (category 1) in 1961 severely affected Ireland and the United Kingdom (UK) with heavy rain and wind, respectively (Hickey, 2011; NDFEM, 2019). Table 2 shows a selection of previous hurricanes (not including tropical storms) that made landfall in European countries. This selection only shows hurricanes that had impacts, excluding high winds, in the country they made landfall on and only includes storms that did not reduce their strength to a so-called “disturbance” before they made landfall. For the creation of this table, the storm tracks available in the NHC Data Archive (NHC, 2022) were checked for all available years (1851-2020). However, in the end, only the hurricanes which were named by the NHC were used for this table because it could be ensured that the literature is in reference to the specific event that could be observed on the NHC past track seasonal maps.

Adding to the former hurricanes mentioned in Table 2, three more PTCs made landfall in European countries, but impacts were “only” described with high winds. These were Hurricane Flossie in 1978 which brought gusts of 167 km/h to Scotland and the Shetlands (Hickey, 2011), Hurricane Floyd in 1993 which caused sustained winds of 130 km/h in Brittany when it made landfall in France (Longshore, 2008; Rappaport, 1993), Hurricane Isaac in 2000 that made landfall in Ireland and resulted in gusts of 83.3-101.86 km/h at the west coast of Ireland (Pasch, 2000), and Hurricane Helene in 2006 which caused gusts of 90.75 km/h at Valentia Observatory in Ireland and gusts of 118.5 km/h on South Uist Island in Scotland (D. P. Brown, 2006).

The frequency of the events gives reason to think about adaptation and communication of measures to deal with the impacts of PTCs that affect Europe, especially as they will become even more prominent under climate change conditions, as described in the next chapter.

Table 2: Lists of former hurricanes that made landfall in European countries and caused impacts.
The EU countries are indicated based on their ISO 3166 code.

Year	Month	Name	Storm Cat.	EU country with landfall	Winds	Impacts	Source
2019	Sep-Oct	Lorenzo	MH	Northern Ireland	<ul style="list-style-type: none"> 85 km/h (10 min) 107.4 km/h gusts 	<ul style="list-style-type: none"> 20,000 customers without power Several Incidents at the coast were Irish Coast-guards needed to respond to 	(Zelinsky, 2019)
2017	Sep	Ophelia	MH	IE		See Chapter 3.2. Hurricane Ophelia	
2006	Sep	Gordon	MH	ES, IE, UK	<ul style="list-style-type: none"> 68.5 km/h (10 min) in A Coruña, ES 183.4 km/h gusts Punta Candierira, ES 129.6 km/h gusts in the UK 	<ul style="list-style-type: none"> Hurricane-force winds Huge amounts of rain in ES, IE and the UK Injuries due to flying debris (ES) 100,000 customers without power (ES) 126,000 people without power in Northern Ireland One injury in Northern Ireland 	(Blake, 2006)
2005	Sep	Maria	MH	IS, UK, NO	<ul style="list-style-type: none"> 83.3-101.86 km/h winds in IS 	<ul style="list-style-type: none"> High winds in IS 131 mm rain in Isle of Skye, Scotland Severe flooding in NO Mudslides in NO due to flood 2 fatalities US\$3.1 million in NO 	(Hickey, 2011; Pasch & Blake, 2006)
2005	Oct	Vince	H	ES	<ul style="list-style-type: none"> 57.4 km/h (10 min) 77.8 km/h gusts in Jerez, ES 	<ul style="list-style-type: none"> Gusts in parts of ES 84 mm rain in Cordoba 	(Franklin, 2006; Longshore, 2008)
1998	Aug-Sep	Danielle	H	UK	<ul style="list-style-type: none"> 111.12 km/h gusts in the UK 	<ul style="list-style-type: none"> Heavy seas and gusty winds Several boats sunk Multiple people needed to be rescued due to dangerous conditions at sea Waves overtopped houses in Cornwall Evacuation at beach areas in Cornwall 	(Hickey, 2011; Longshore, 2008; Pasch, 1999)

Continuing Table 2

Year	Month	Name	Storm Cat.	EU country with landfall	Winds	Impacts	Source
1996	Oct	Lili	MH	UK	<ul style="list-style-type: none"> 83.3 km/h (10 min) in Alderney, UK 148 km/h gusts in Swansea, UK 	<ul style="list-style-type: none"> 1m storm tide in the Thames 4.6 m waves in the Bristol Channel 500 holiday cottages damaged 13 m waves at sea Oil drilling platform snapped free Multiple-day power loss to thousands of people 25 m sailboat was beached 5 people killed Costliest storm after 1987 with \$US300 million 	(Lawrence, 1996; Longshore, 2008)
1992	Oct	Frances	H	ES	/	<ul style="list-style-type: none"> Heavy rain in western ES and northern PT 	(Longshore, 2008)
1987	Aug	Arlene	H	PT	<ul style="list-style-type: none"> 63 km/h (10 min) 	<ul style="list-style-type: none"> 127 mm rain in Oporto, PT Flooding in Oporto, PT Storm was felt up to Madrid 	(Longshore, 2008)
1986	Aug	Charley	H	UK, IE	<ul style="list-style-type: none"> Average wind of 84 km/h over UK and IE 	<ul style="list-style-type: none"> Destroyed power lines in the UK Uprooted trees in the UK Several million pounds of damage in the UK 127 mm rain in one day in IE + severe flooding 5 deaths in the UK and 6 in IE 	(Hickey & Conolly-Johnston, 2012; Longshore, 2008; NDFEM, 2019)
1967	Sep	Chloe	H	FR	<ul style="list-style-type: none"> 74 km/h gusts 	<ul style="list-style-type: none"> Sinking of German hip "Friedrich Schultze" → 3 men drowned and 11 were missing 	(Delgado & Landsea, 1971; Sugg & Pellissier, 1968)
1966	Aug-Sep	Faith	MH	NO	<ul style="list-style-type: none"> 74 km/h (10 min) in EU 161 km/h gusts in NO 	<ul style="list-style-type: none"> Heavy winds in NO and generally in North EU One person drowned due to a ferry sinking in DK 	(Longshore, 2008)
1961	Sep	Debbie	H	IE	<ul style="list-style-type: none"> 126 km/h (10 min) 171 km/h gusts 	<ul style="list-style-type: none"> 18 deaths (IE and Northern Ireland) Hundreds of collapsed houses in IE and the UK One of the most expensive natural catastrophes in the history of the area 	(Hickey, 2011; Longshore, 2008; NDFEM, 2019)
1957	Sep	Carrie	MH	IE	/	<ul style="list-style-type: none"> Caused disastrous waves and flooding in IE/UK 	(Moore, 1957)

3.1.3. Hurricanes under Climate Change

Several studies suggest that TCs will become more frequent and more intense under climate change conditions due to an increased number of TCs undergoing ET (Baatsen et al., 2015; Haarsma et al., 2013; Liu et al., 2017; Michaelis & Lackmann, 2019).

This reintensification of PTCs after their ET poses a threat to northern and western Europe. This was already found by Hart and Evans (2001) and Semmler et al. (2008), who analysed TCs in the past.

Hart and Evans (2001) found that from 1950 46% of TCs underwent ET by using the climate model of ERA40. Between 1979 and 1993 51% of TCs that underwent ET regained strength. They also found that the reintensification is dependent on the intensity of the system and the speed with which the TC is crossing the unfavourable conditions of the ET period: First, the stronger the TC is before the start of the transition, the longer it can survive the unstable conditions. Second, the faster the ET is completed, the better the re-strengthening. In comparison, Semmler et al. (2008) used the model of RCA3, which is derived from ERA40 but has a higher resolution. They concluded that there has been an increase in TCs in the period between 1985 and 2000. They found that 44% of the TCs undergo ET. This is similar to the findings of Hart and Evans (2001). However, in the study, only 12% re-intensified under the standard climate. They also analysed the TCs under a climate where there has been an increase in atmospheric temperature and SST of 1 K respectively. In such a scenario 48% of all TCs would have undergone ET and 24% of TCs would have regained strength after ET. The different results are the result of the higher resolution of the model.

The transitioning TCs are not only considered a potential danger to Europe in the past, also today several authors have used climate models to predict the changes in TCs, ETs and PTCs under future climate conditions. In the following, the results will be presented.

Michaelis and Lackmann (2019), Haarsma et al. (2013), Baatsen et al. (2015) and Liu et al. (2017) predict that ET onset density and ET completion density will increase in the north and east of the northern Atlantic. The location where completion happens is expanding further eastwards close to the coast of Ireland. There will be a shift of the TC generation area to the subtropical regions through a decrease in vertical wind shear and an increase in SST resulting in a favourable environment for TCs in the subtropics and longer latent heat release.

Subsequently, TCs will reach the midlatitudes more likely before they disperse. Additionally, more TCs re-intensify through latent heat release by diabatic heating. Thus, TCs can become a serious threat to western Europe (Haarsma et al., 2013).

Further, there is an 18% increase in TCs predicted in future simulations. Also, the ET occurring region will shift northwards to 48-58°N due to the mentioned changes, which increases North Atlantic ET by 40%. This will lead to a higher probability that PTCs will reach Europe and will also intensify them. The median minimum sea level pressure will be 6 hPa lower than today (Michaelis & Lackmann, 2019).

Due to the eastwards shift of the TC genesis region, there will be an increase in autumn storms in Europe “from 15 in the present [climate] to 23 in the near future and 37 in future simulations.” (Baatsen et al., 2015, p. 954). In this context, the present, near future and future, describe the years 2002-2006, 2030-2040, and 2094-2098, respectively. Additionally, the storm intensity increases in a warmer climate (Baatsen et al., 2015; Dekker et al., 2018). Through the increase of intensity, TCs that made landfall in the Caribbean or the US will have the potential to still move towards Europe afterwards. Moreover, through the shift of the development region towards Europe, the peak intensity region of the PTCs, which is nowadays in front of the coast of the British Isles will shift towards Scandinavia and the North Sea in the future (Baatsen et al., 2015). Thus, Ireland will experience stronger autumn storms instead of already dissipating ones, as can be seen in Figure 6. In addition, Liu et al. (2017) state, that future ET events will occur in two paths, where one path will affect the northeast of the United States and the other moves northeast and affect western Europe.

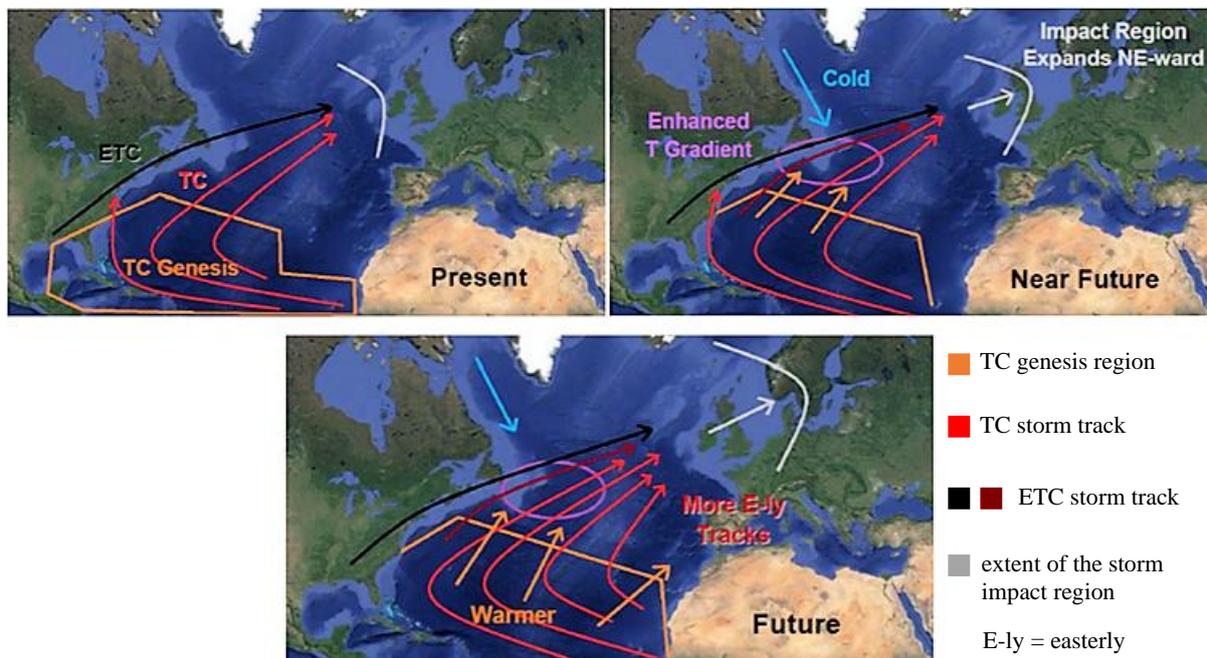


Figure 6: Changes in tracks of severe autumn storms impacting western Europe in the present, near future and future climate. Source: Baatsen et al. (2015, p. 963)

In numbers, it is found that, compared to midlatitude cyclones, the proportion of PTCs that hit northern Europe with storm-force winds is ten times greater. Even less than 1% of cyclones that form during a hurricane season are PTCs, they still cover 8.8% of all cyclones forming in a

hurricane season that affect northern Europe with storm-force winds (Beaufort scale 10) and PTCs are significantly more intense than ETCs (Sainsbury et al., 2020). If the occurrence of TCs increases as suggested by the authors previously mentioned, Europe can be affected much more frequently by PTCs. This can cause devastating impacts on people, the economy and livelihoods.

However, in the end, all authors state that as climate models are too coarse for storm predictions, research needs to develop. In this regard, new models are created which have higher resolution and allow for more localised future storm predictions.

Nevertheless, the authors used different kinds of climate models with different emission scenarios: Baatsen et al. (2015), Haarsma et al. (2013) and Liu et al. (2017) used the Representative Concentration Pathway (RCP) 4.5 emission scenario, while Michaelis and Lackmann (2019) analysed the RCP 8.5 and Semmler et al. (2008) used a 1 K increase in SST and atmospheric temperature. All mentioned authors conclude that the number of TCs and following the number of transitions, increase with warmer SST in future climates. Hence it is more likely that PTCs will reach Europe more frequently under future climate conditions. The increase in hurricanes in the future gives reason to assess the risk perception and risk communication strategy of Cork.

3.2. Hurricane Ophelia

One of these powerful PTCs was Ophelia. It was the most eastern Atlantic hurricane as well as the strongest hurricane ever recorded in the eastern Atlantic, with a category 3 on the Saffir-Simpson Scale (Byrne & McDonnell, 2017; Hickey, 2017; Met Éireann, 2018b; NDFEM, 2019; Rantanen et al., 2020; Stewart, 2018). It was the sixth MH in the hurricane season of 2017 which was an unusual season with 10 hurricanes in total, seven tropical storms and one tropical depression (NHC, 2018). This was the first time since 1893 that 10 hurricanes appeared in a single season (Hickey, 2017). How Ophelia generated, what its characteristics were, and which impact it had, is described in the following chapters, to provide an understanding of the severity of the event.

3.2.1. Generation

Ophelia's generation started at the beginning of October when a low-pressure system formed and developed a shallow weak convection which became stronger over the 27°C warm water. Each of these convections resulted in an intensification of the system and a gale area formed out of the disturbance until a tropical storm was established on the 9th of October. Trapped between two ridges, one in the north and one in the south, Ophelia could strengthen over the warm water. The effect was boosted by 2-3°C lower than average temperatures in the mid- and upper-level, thus it became a tropical storm in the morning of the 11th of October with wind speeds of 101.86 km/h, and a category 1 hurricane in the evening that day. Between the 12th

and 14th of October air masses coming from Canada destroyed the northern ridge resulting in Ophelia turning to the northeast. During this period Ophelia's travel speed increased from 9.26 km/h to 37 km/h. This came together with an increase in windspeed of the system. On the 13th of October, it had wind speeds of 166.68 km/h and on the 14th, they increased to 185.2 km/h due to a decrease in vertical wind shear, which made it a category 3 hurricane. On the 15th the ET began and high vertical windshear of 74 km/h and lower SST of 23°C caused a weakening of the system. After ET completion in the early hours of the 16th of October, the PTC had winds of 138.9 km/h and moved towards Ireland with a speed of 74 km/h, where it made landfall at 10 a.m. local time at Valentia Observatory, Co. Kerry (Met Éireann, 2018b; Stewart, 2018). Figure 7 shows the track Ophelia travelled towards Ireland and Figure 8 shows a schematic overview of the most important phases of Ophelia's development.

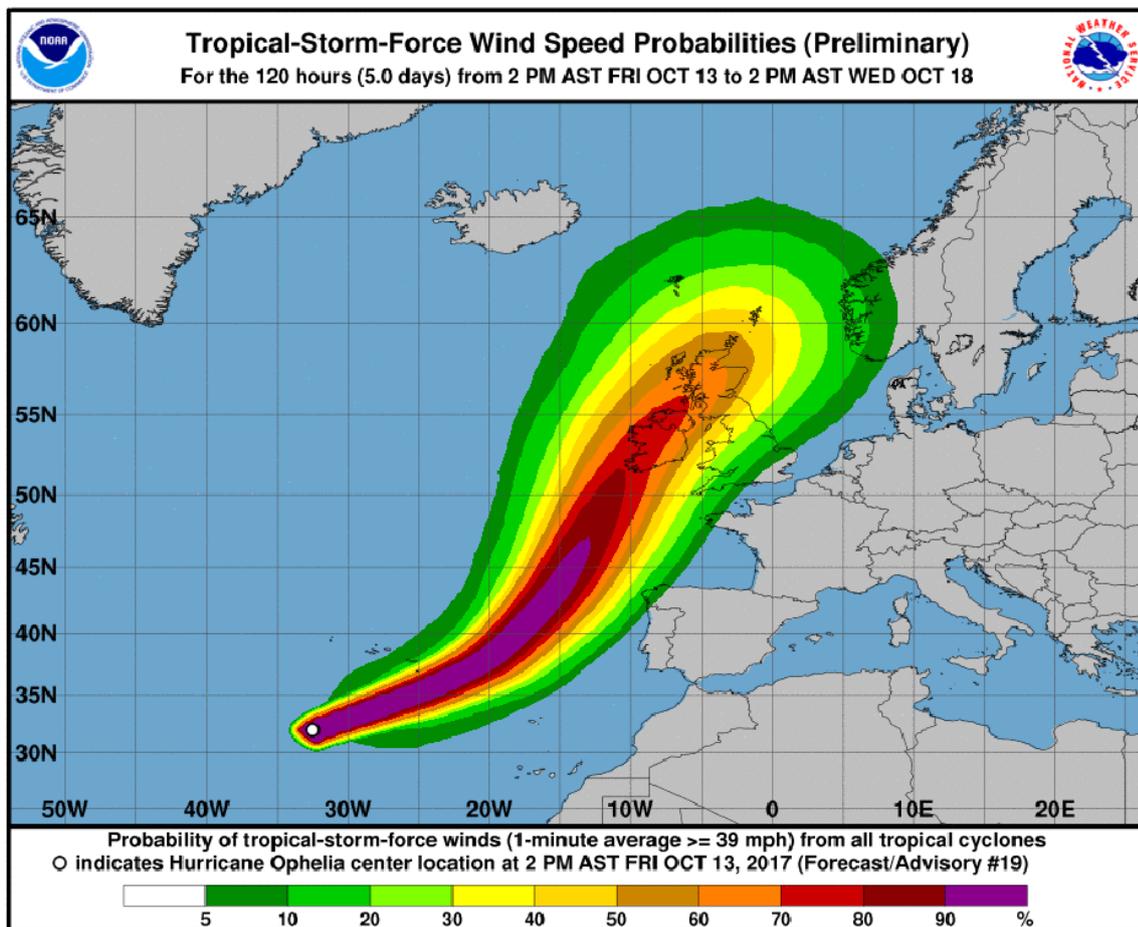


Figure 7: Track of Ophelia and the probability of storm-force winds
 Source: NOAA in Met Éireann (2018b)

Development of Hurricane Ophelia 2017

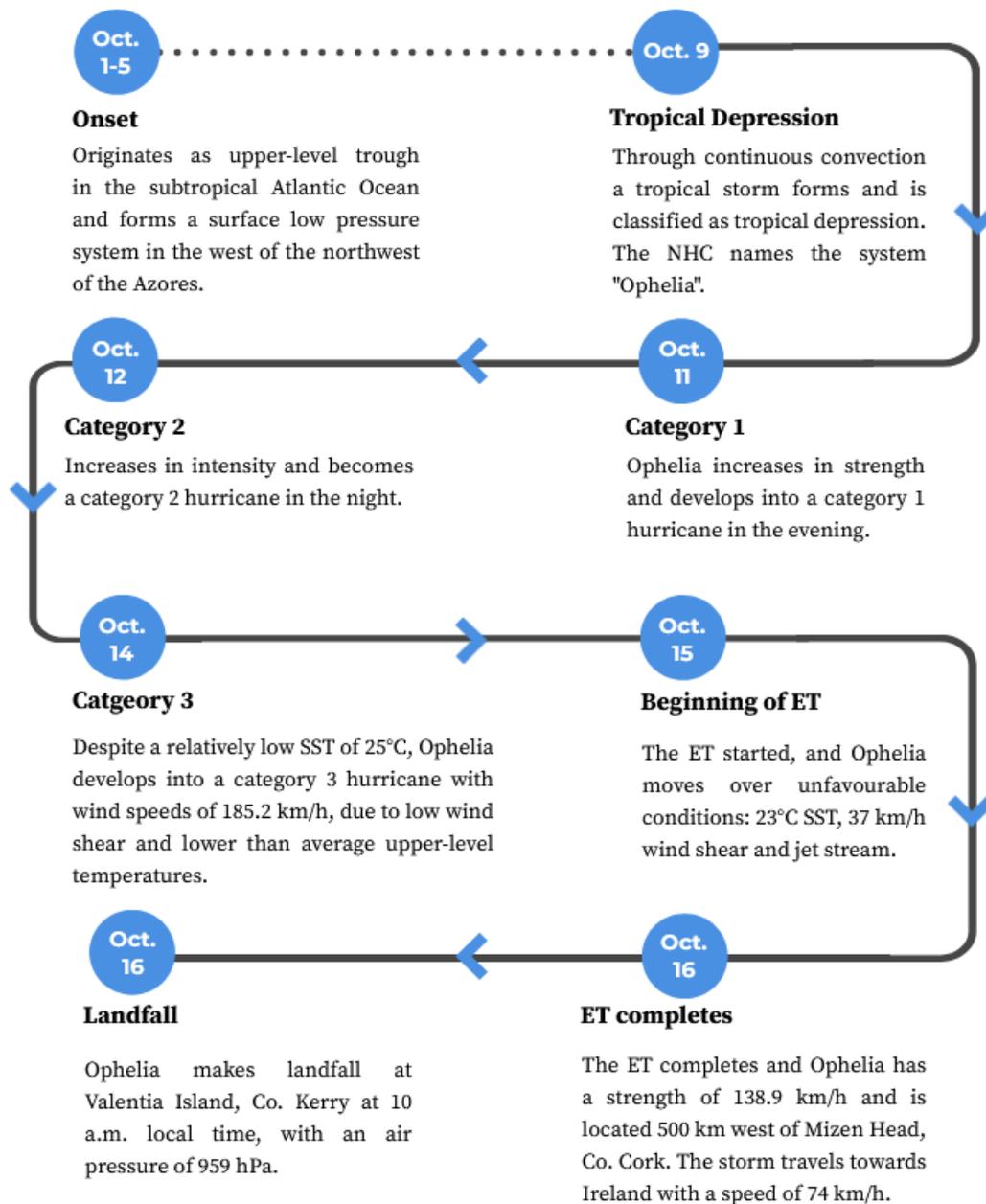


Figure 8: Timeline of the generation of Hurricane Ophelia.

Graphic created by author, based on data from Met Éireann (2018b) and Stewart (2018)

3.2.2. Characteristics

When Ophelia made landfall it had a pressure of 959 hPa (Met Éireann, 2018b; Stewart, 2018), which is comparably low to an average atmospheric pressure of 1013.2 hPa (DWD, 2022b). Additionally, the PTC caused unusually warm temperatures with more than 19°C at Valentia observatory at 6 a.m. on the 16th of October. Waves were exceptionally high during the storm, at 4 p.m. on the 16th of October the M5 buoy, located on the southeast coast of Ireland measured a wave height of 17.81 m which is the highest wave the M5 buoy has ever recorded (Met Éireann, 2018b). The Kinsale Energy Natural Gas Platform, offshore of Old Head of Kinsale, recorded a wave height of 26.1 m (Stewart, 2018). The strongest 10 min sustained windspeed

was reported from Roches Point at 115 km/h as well as the strongest gust at 156 km/h (Met Éireann, 2018b; Stewart, 2018). However, before Ophelia made landfall there was a gust of 191 km/h recorded at Fastnet Rock (Met Éireann, 2018b). Figure 9 shows the location of the recorded wind speeds mentioned in Table 3.

There was no devastating rain event during Ophelia, as is usually connected to hurricanes. This can be related to the fact, that the strongest rain was located on the north-western side of Ophelia and because the system made landfall in the southwest of Ireland most of the associated rain fell over the Atlantic Ocean (Met Éireann, 2018b; NDFEM, 2019; Stewart, 2018). Additionally, there was no severe flooding due to storm surges as Cork was fortunate that the hurricane did not coincide with high tide (Towey et al., 2017).

Table 3: Recorded wind speeds during Hurricane Ophelia in Cork and its surroundings.

Location	Elevation in m	10 min sustained windspeed in km/h	Gust in km/h
Roche's Point Lighthouse	40	115	156
Kinsale Energy Gas platform	Sea level	111	140
Sherkin Island	21	106	137
Cork Airport	155	87	131
Moore Park, Fermoy	46	67	115
Fastnet Rock	70	/	191

Based on data from Met Éireann (2018) and Stewart (2018)

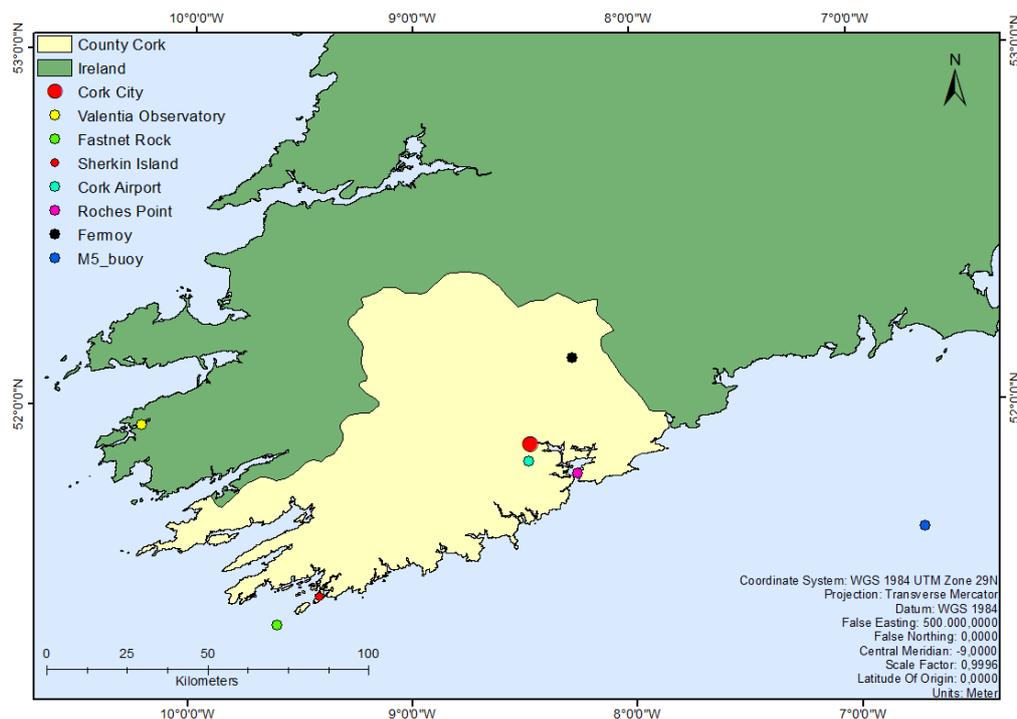


Figure 9: Locations of recorded windspeeds
Map created by author. Data: Geofabrik (2021), Hijmans et al. (2012), Marine Institue (2022)

3.2.3. Impact

As mentioned previously there was no severe damage in Cork through heavy rain or storm surge, but the aforementioned strong winds did lead to severe damage in the county and across all of Ireland. The wind caused numerous trees to fall which resulted in three deaths in Ireland. The fallen trees blocked many important roads. Especially the N25, N71, N73 and M8 – all in Cork – were blocked by trees (NDFEM, 2019). In total, six national roads, 35 regional roads and 600 local roads were affected by fallen trees. This caused the isolation of Great Island and Cobh and in turn impacted the response of ambulance services (Cork County Council, 2017). The trees also brought down power lines which resulted in the disruption of the energy supply (Towey et al., 2017). Figure 10 shows the mentioned locations that have been impacted by Ophelia.

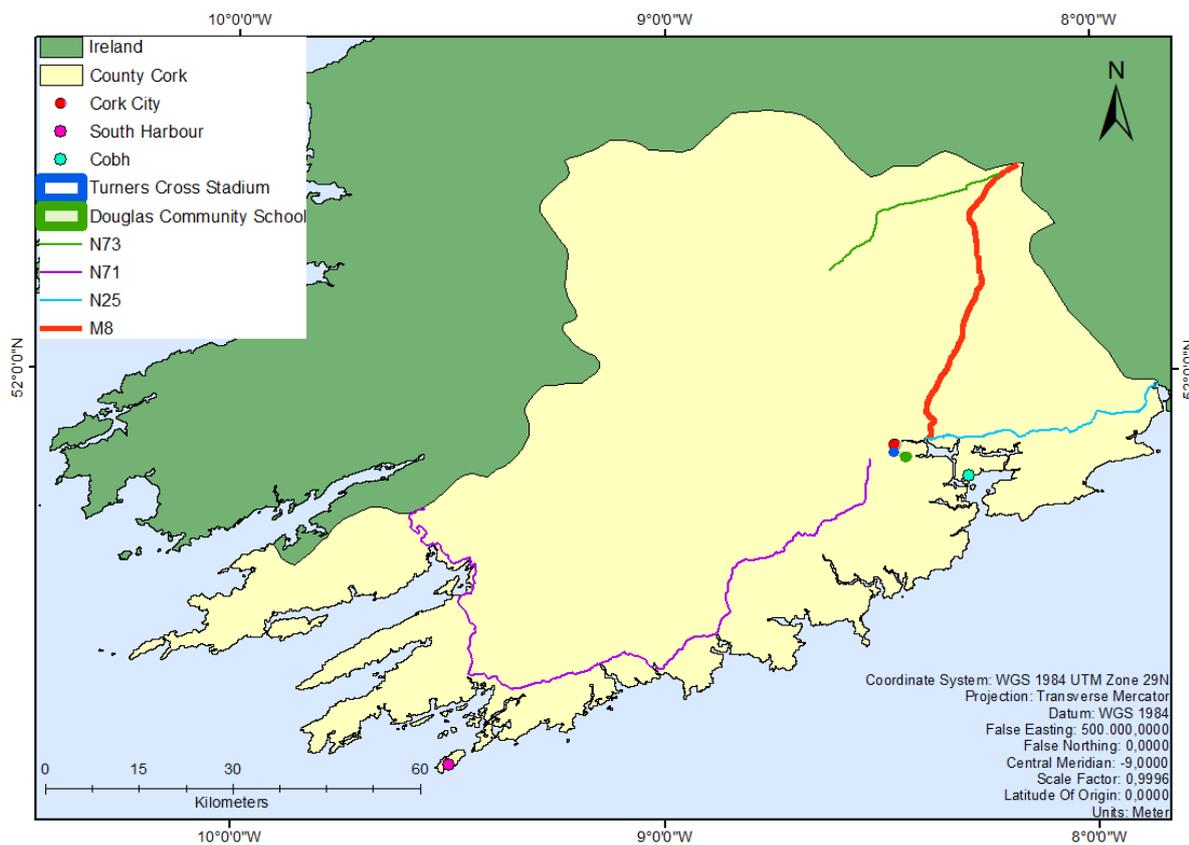


Figure 10: Impacted locations through Ophelia

Map created by author. Data: Eurogeographics (2021), Geofabrik (2021), Hijmans et al. (2012)

The power outages were a major issue: At the peak of the storm, 385,000 premises were without power, mainly in the south and southeast of the country (NDFEM, 2019; RTE, 2017; Towey, 2018). In Cork alone, 90,000 customers were affected (Cork County Council, 2017). This was the largest number of outages that occurred in the history of the Electricity Supply Board (ESB), the Irish energy provider (Siggins, 2017).

Another consequence of the power outages were the water supply issues. A maximum of 109,000 customers were without water supply in the whole country this was due to power outages in wastewater treatment plants (WWTPs) and water pumps (NDFEM, 2019; RTÉ, 2017). In Cork, approximately 58,000 customers were affected by the disruption of water supply and 19 WWTPs and 40 pumping stations were impacted by the power outage. This resulted in the spilling of untreated wastewater into the sea, rivers, lakes and estuaries (RTÉ, 2017). Additionally, the remote telemetry system lost power, which made it difficult to monitor treatment plants, pumping stations and reservoirs (Cork County Council, 2017).

Not only power lines were affected but also telecommunication poles and cables of the mobile provider “Eir”. Around 150,000 customers were without broadband, telephone and mobile service, with Cork being the area worst impacted with 51,000 customers without phone service (RTÉ, 2017). Where the masts were not damaged the power outages affected the provision of the telecommunication service (NDFEM, 2019).

Furthermore, the strong winds caused damage to several buildings throughout the country. According to estimates, Cork City's private property damage amounts to more than €50 million (Towey et al., 2017). Especially the Douglas Community School and the Turners Cross Stadium were badly damaged (Towey, 2018). Overall, 302 individual properties were impacted. The impact ranged from damaged roofs and falling slates to damages to sheds and boundary walls. The main impact was recorded in Cobh. Moreover, there is estimated damage of €439,600 to council properties, like council buildings, cemeteries, walkways, public pools and parks (Cork County Council, 2017). Also, coasts and beaches were affected, like South Harbour in Cape Clear, coastal walls and Bank Pier, resulting in damage of approximately €361,500 (Cork County Council, 2017, p. 11).

Due to the severity of the event and the probability of an increase of PTCs in the future under a warmer climate, risk communication and warnings to the public and between the emergency management stakeholders must be accurate. Thus, the next chapter discusses the EMS for severe weather in Ireland.

3.3 Emergency Management of Severe Weather in Ireland

Emergency Management in Ireland is strictly structured and laid out in the Framework for Major Emergency Management (FMEM) of 2006 which replaced the previous Framework for Coordinated Response to Major Emergency of 1984. This framework lays down the general EMS and includes several guidance documents which concentrate on special emergencies, like guidance document 14, which focuses on severe weather emergencies (Department of Housing, Planning and Local Government, 2006).

An emergency is hereby defined as an “unexpected and potentially dangerous situation, requiring immediate action” (Department of Housing, Planning and Local Government, 2006, p. 15). If a major emergency occurs there is a certainty that the emergency will cause death and injuries, as well as destruction to infrastructure, the environment and damage to the economy. For these types of emergencies, national resources need to be mobilised to ensure a structured response and recovery. Thus, the documents guide to a uniform terminology so that all involved Principal Response Agencies (PRAs) can handle the emergency more efficiently. The Irish EMS is displayed in Figure 11 for a better overview. It describes the connections between the different national and local groups involved in severe weather management which are described in the following.

The PRAs are the Local Authority (LA), which is the leading PRA when there is a severe weather emergency, the Health Service Executive (HSE) and the An Garda Síochána (AGS), which is the Irish police. Further, it demands, that each PRA should have an emergency management plan (EMP) for different types of emergencies, as well as sub-plans for those. For example, the LA is the lead PRA in severe weather and thus has a very detailed EMP for those types of emergencies. The remaining PRAs should have sub-plans, which consider the EMP of the LA during severe weather and should support the procedures of the LA in such an event. Moreover, the FMEM assigns tasks like risk assessment, implementing mitigation measures, planning and preparedness for times when no emergency is acute to the PRAs. This involves of course the preparedness of the public and making them aware of possible risks, as well as communicating risks, how to minimise them and what each person can do to protect themselves from such hazards (Department of Housing, Planning and Local Government, 2006).

The PRAs are responsible for the local management of the emergency. This would be the lower part of Figure 11 up to the “Regional Co-ordination Group” (RCG). The RCG is not always needed, only if the leading PRA decides, that the incident affects more than one area of PRAs, and regional coordination would benefit response and recovery, to combine the efforts of all involved PRAs. The leading PRA, in case of severe weather the LA, which requested the RCG would also chair it. The advantages of the RCG are mostly better coordination between Local Co-ordination Groups (LCGs) as well as different regional AGS, HSE, and LA divisions. But mostly it facilitates the coordination of national or regional agencies like the ESB or the defence forces (Department of Housing, Planning and Local Government, 2020). However, if a RCG is not necessary the LCG is leading the local efforts of response. The LCG is assembled by the LA in case of severe weather. The LCG has the task of providing information about the event to the public and media regularly and additionally overlooks and combines the efforts of each Crisis Management Team (CMT) of each PRA. These CMTs are strategic management groups in each PRA and usually consist of senior managers of the agency. The CMTs support their

representatives in the LCG, amongst others with the information of their On-site Co-ordination Centres. Vice versa the representatives of each PRA who are working in the LCG provide them with information from there. This is done in regular set-up intervals, between the members of the LCG as well as between the LCG PRA members and their CMTs. As lead PRA the LA CMT has also a severe weather assessment team (SWAT) that monitors the information given by Met Éireann and provides them to the LA CMT, which then provides these to the LCG. In general, the FMEM is a bottom-up approach but can be activated top down, from the national level as well. (Department of Housing, Planning and Local Government, 2006). For example, in case of a major emergency, like PTC Ophelia.

With Ophelia, a national approach was activated and thus a national EMS. In case of severe weather, the Lead Government Department, which in this case is the National Directorate for Fire and Emergency Management (NDFEM) from the Department of Housing, Local Government and Heritage, would monitor the warnings and forecasts issued by Met Éireann. If a weather warning is issued, the NDFEM decides whether it wants to convene the National Emergency Co-ordination Group (NECG), depending on the severity and size of the area of the warning. The NDFEM requests the assembling of the NECG at the Office for Emergency Planning (OEP), which is part of the Department of Defence. The OEP maintains the National Emergency Coordination Centre (NECC), which is the national emergency management room and can convene the NECG there. The NECG consists of the members of the Government Task Force (GTF) which consist of senior managers of all government departments and lead agencies. In the first NECG meeting, all members of the GTF need to participate. Afterwards, only the GTF members of relevance for the specific emergency will join the meeting. The NECG is in contact with all assembled Regional/Local Co-ordination groups and provides information on the current situation and vice versa (Government of Ireland, 2021).

All actions described above, especially the request of the NECG are triggered by warnings that are issued by Met Éireann. There are yellow, orange and red weather warnings. Each warning has different thresholds that need to be reached to disseminate a specific warning. This system was introduced in 2013. Usually, warnings are issued around 10 a.m. by the duty forecaster or when necessary at other times but not more than 48 hours in advance of the event (Department of Housing, Planning and Local Government, 2020). The meaning of the different warnings for wind and rain (as these are hurricane-related hazards) are shown in Figure 12.

Severe Weather Warning Emergency Management Structure in Ireland

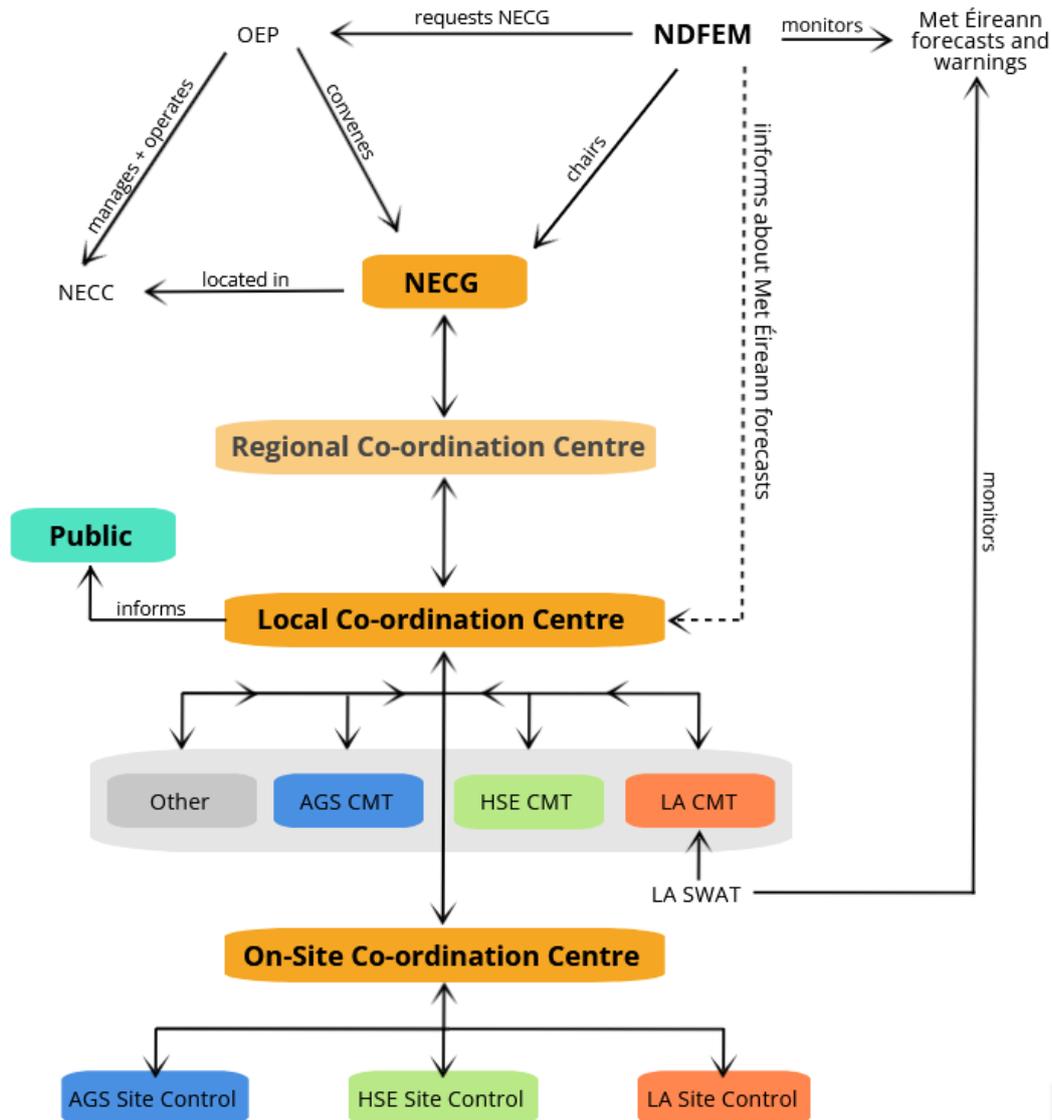


Figure 11: Severe weather warning emergency structure in Ireland.
 Graphic created by author based on data from Department of Housing, Planning and Local Government (2006), Department of Housing, Planning and Local Government (2020), and Government of Ireland (2021)

In Guidance Document 14 - A Guide to Severe Weather Emergencies of the Department of Housing, Planning and Local Government (2020), strategies for risk communication are commended. The communication, on the national and local levels equally, should start with the improvement of community resilience through active public engagement in emergency management. This increases awareness and preparedness for severe weather emergencies. Through better preparedness, vulnerability is reduced which leads to a better response and recovery and avoids duplication of actions. But not only the preparational communication should be of focus. The communication within each PRA, with other PRA's Regional Coordination, national agencies, agencies such as the ESB and with local community groups and organisations is important

during the event itself. Especially during emergency communication with the public, the message should be carefully considered and published via several media channels, like agency website information, social media (SM), television, and national and local radio. In the case of specific local areas identified as being at risk, emergency vehicles and personnel should be considered to deliver messages personally. For communication, it is of utmost importance that only verified, relevant and timely information is collected and distributed. This information should be delivered regularly via all the channels mentioned above to local and national media, local and national political bodies and relevant government departments and national headquarters. Further, it is important that requests can be answered. Thus, call centres should be established to take calls quickly and provide relevant responses.

Weather Status	Status Yellow	Status Orange	Status Red
Description	Weather that does not pose a threat to the general population but is potentially dangerous on a localised scale.	Infrequent and dangerous weather conditions which may pose a threat to life and property.	Rare and very dangerous weather conditions from intense meteorological phenomena.
Wind	<ul style="list-style-type: none"> Widespread mean speeds between 50 - 65km/h Widespread gusts between 90 - 110km/h 	<ul style="list-style-type: none"> Widespread mean speeds between 65 - 80km/h Widespread gusts between 110 - 130km/h 	<ul style="list-style-type: none"> Widespread mean speeds in excess of 80km/h Widespread gusts in excess of 130km/h
Coastal Wind Warnings	Gale force 8 / Strong Gale Force 9	Storm Force 10	Violent Storm Force 11 / Hurricane force 12
Rain	<ul style="list-style-type: none"> ≤ 20mm – 30mm in 6 hrs ≤ 30mm – 40mm in 12 hrs 30mm – 50mm in 24 hrs 	<ul style="list-style-type: none"> ≤ 30mm – 50mm in 6 hrs ≤ 40mm – 60mm in 12 hrs 50mm – 80mm in 24 hrs 	<ul style="list-style-type: none"> > 50mm in ≤ 6 hrs > 60mm in ≤ 12 hrs > than 80mm in ≤ 24 hrs

Figure 12: Met Éireann's weather warning explanation. Source: Met Éireann (2022)

However, even though the FMEM focuses on risk mitigation at regional and local level, it does not involve a paragraph about climate change and preparatory measures for its effects through communication (Medway et al., 2022). Especially with the focus that PTCs will be more frequent in the future, the inclusion of CCA into the FMEM should be considered. The next chapter explains the concepts of risk perception and risk communication and how this knowledge can cause reduce vulnerability.

4. The Concept of Risk Perception and Risk Communication

This section defines the terms risk perception and risk communication and shows how these concepts are closely interlinked. For this chapter, the literature search was conducted as described in chapter 3. Additionally, for the explanation of specific terms, also institutional websites were used as the United Nations, for example. The results for risk communication literature were exceptionally voluminous. Hence the focus was set on risk communication of hurricanes in particular and NHs with hurricane-related hazards, such as wind and floods.

Before referring to risk communication and risk perception a few terms need to be clarified: First, the risk that is talked about in this work is disaster risk³. A disaster is an event that alters and/or disrupts the everyday life of a society due to a hazardous event. It affects social, economic, and environmental aspects and usually requires an immediate emergency response (Intergovernmental Panel on Climate Change [IPCC], 2012). Generally, disaster risk is defined as “the probability of an outcome having a negative effect on people, systems or assets” (UNDRR, 2022c). A widely used formula for risk definition is “Risk = Hazard x Exposure x Vulnerability”.

In this formula hazard is a “potential occurrence of a natural or human-induced event that may cause loss of life, injury or other health impacts, as well as damage and loss of property, infrastructure, livelihoods, service provision, and environmental resources.” (IPCC, 2012, p. 44). As this work focuses on hurricanes, we can focus only on the natural event that might affect the human and natural environment negatively (Federal Emergency Management Agency [FEMA], 2022). However, not every NH is a disaster. A NH can only become a disaster if there are adverse effects on the environment (UNDRR, 2018).

Exposure is the location or situation of human assets or people in hazard-prone areas (UNDRR, 2022b). However only because one is exposed does not automatically mean that one is vulnerable.

Vulnerability can be described as the “predisposition to be adversely affected” (IPCC, 2012, p. 17). The factors and processes that lead to vulnerability are manifold and can be found in a variety of contexts, like social, economic, political, cultural, institutional, and environmental. It also includes the ability to recover after a disaster (IPCC, 2012).

³ In this work the terms risk and disaster risk will be used interchangeably.

4.1. Risk Perception

“Risk perception, in general, denotes the processing of physical signals and/or information about potentially harmful events or activities, and the formation of a judgement about seriousness, likelihood and acceptability of the respective event or activity” (Renn, 2008, p. 98).

This definition makes it clear that risk perception is not an easy concept and that it is important to understand this concept in order to communicate risk accordingly.

According to Renn (2008), there are four ‘schools of thought’ also called “classes of psychological variables” (p.99) to understand the drivers of risk perception. The ‘semantic images’ are not discussed here, as these images have not been examined in empirical experiments (Renn, 2008). The ‘Cognitive heuristics’ and the ‘Psychometric factors’ will be discussed in this chapter. The ‘attention and selection filters’ will be explained in the risk communication chapters, as they fit better in the context of communication in this work.

In the field of cognitive heuristics, there is a basic assumption that people try to avoid risks if the possible losses are high, and they do not avoid risks if it is possible to achieve rewards while being in that risk. Many people moderate their risk-taking behaviour by adopting an optimal risk strategy that does not maximize their rewards but provides a good pay-off and the avoidance of catastrophic events. The benefits one could gain from taking the risk are weighed against the risk itself before a decision or a ranking of the risk is done (Slovic, 2000). This is, for example, the case when it comes to flooding. The benefit of the nutrients brought on land by the water could prevent farmers from taking protective measures for their fields.

However, people undergo typical biases while assessing the risk and the benefits. For example, they do not refer to probabilities while assessing risks. One needs to know that the concept of “risk” is already differently understood by experts and by lay people. Slovic (1987) states that an expert understands risk more like the annual fatalities an event causes, while a layperson usually connects the term risk with catastrophic potential and threat than with the concept of fatalities. Even when a hazard occurs rarely, but causes a lot of fatalities, laypeople tend to recognize the risk as high because of its potentially high impact, while experts would consider the risk rather low, due to the seldomness of the event (Fischhoff et al., 1993).

Hence, four biases are identified and summarised by Renn (2008). These are shown in Table 4.

Table 4: Intuitive biases of risk perception

Biases	Description
Availability	Events that come immediately to people's minds are rated as more probable than events that are of less personal importance
Anchoring effect	Probabilities are estimated according to the plausibility of contextual links between cause and effect, but not according to knowledge about statistical frequencies or distributions (people will 'anchor' the information that is of personal significance to them)
Representation	Singular events experienced in person or associated with the properties of an event are regarded as more typical than information based on the frequency of occurrence
Avoidance of cognitive dissonance	Information that challenges perceived probabilities that are already part of a belief system will either be ignored or downplayed

Source: Renn (2008, p. 103)

The field of psychometric factors goes beyond the analysis of harm, probability and benefits. It views risks as a personal assessment of one's concerns or expectations around unfavourable outcomes of actions. For example, Fischhoff et al. (1978) and Slovic (1987) analysed different contextual factors that individuals use when they assess risk. These are:

1. Expected number of fatalities and losses
2. Catastrophic potential
3. Risk related characteristics
4. Situation related characteristics
5. Beliefs associated with the cause of risk
6. Stigmatisation
7. Emotional responses
8. Personal involvement

The first point describes the number of fatalities; however, these numbers are not the main trigger for riskiness for people. According to Renn (1990), they only explain less than 20% of the decision. The second point describes the perception of people similar to the field of cognitive heuristics. People feel more catastrophic potential when there is a heavy consequence, even though there is low probability and less catastrophic potential if the risk is more probable, but the consequences are low or medium.

Number three is influenced by the characteristics of a risk. Risks are perceived as dangerous when there is a high feeling of dread. However, dread is not the only important factor. For example, if a risky activity is done voluntarily the person is not perceiving the risk as high. Instead, if the person is at a risk involuntarily, the risk will be perceived as higher (Slovic, 1987;

Slovic et al., 2004). Further, there is an amount of risk where people still feel comfortable, especially since they will adjust their behaviour when there are safety measures in place. Safety measures lead to more risky behaviour (Botterill & Mazur, 2004). For example, people will participate in climbing activities more likely if they are secured with ropes than if they are asked if they would climb without security measures.

On the other hand, Slovic (1987) states that a disaster that occurs in a well-understood system, where the risk is well realised is not perceived as very risky. For example, a train crash can cause a lot of fatalities however, people do not perceive train rides as risky. In contrast to this, he describes the unknown system of nuclear power. Because there is a lack of understanding in handling nuclear power risk, people tend to perceive this type of power generation as very risky. Also, the amount of personal control over a situation is influencing the perception of risk. If one has control over a situation the risk is seen as less severe. Contrary, the risk is felt higher if one has no control over the situation. An example would be a ride with a car. This ride feels less risky than flying in an aeroplane, even if statistically more people die in car accidents than in plane crashes (Renn, 2008). This is because one has control over the car, while in the plane one must trust in the abilities of the pilot. Personal control and voluntariness of risk are as well influencing number four of the list above.

If the beliefs associated with the cause of risk are negative the risk will be perceived as riskier than if the source of risk is associated as neutral or even as positive. A person who associates corruption and profit guidance with industries will see pollutants as riskier than a person that associates industries with the supply of new goods that benefit society. The pollutants might be an unliked by-product, but not a risk (Clarke, 1989).

Stigmatisation and emotional responses are quite similar and are both influenced by personal feelings. Negative connotations with a topic, like nuclear power or waste depositories, directly lead to a riskier attitude towards the certain cause of risk (Zwick, 2006). Thus, stigmatisation influences the perception of risk. Moreover, risk is perceived differently depending on the social status of a person. The culture, personal emotions as well as the personal decision process is influencing the perception of risk. (Fischhoff et al., 1993; Garvin, 2001). Besides, "Risk is subjectively defined by individuals who may be influenced by a wide array of psychological, social, institutional and cultural factors" (Slovic, 2000, p. xxiii). Hence, many personal factors additionally influence the perception.

The last number describes the influences of involvement in a hazardous activity. People tend to have a lower risk perception if they are involved in the activity causing the risk. For example, people who regularly consume alcohol, do a certain sport or travel do not associate the risk of

the activity as high (Hazard & Lee, 1999). This can be again connected to control and voluntariness.

Due to all these personal influences on risk perception, it is important to understand the perception of the people the risk communication is directed to, to create the wanted reaction. Otherwise “the mission of risk communication would be conceptually simple” (Fischhoff et al., 1993, p. 186). This is why risk communication needs to be a bilateral process between experts and the public where the knowledge of every side is accepted and understood as valuable (Slovic, 1987) and why risk communication needs to be connected to risk perception. Without an understanding of risk perception, communication can not succeed in reaching the audience. In the next chapter, risk communication will be explained and further connected to risk perception.

4.2. Risk Communication

“Risk communication is an interactive process of exchange of information and opinion among individuals, groups, and institutions. It involves multiple messages about the nature of risk and other messages, not strictly about risk, that express concerns, opinions, or reactions to risk messages or to legal and institutional arrangements for risk management.” (National Research Council [NRC], 1989, p. 21).

Very important in this definition is that risk communication is a process. In the best case, this process is participatory, involving various stakeholders and the public. Risk communication does not only stand for risk messaging in times of approaching NHs. While risk messaging is part of risk communication, it only focuses on the one-way information of institutions on a hazard to the public. This is also important but does not fill the complete communication process which also includes an exchange of success of communication and education on the different perceptions of the risks by different institutions, within institutions and from experts to non-experts and vice versa (NRC, 1989).

Therefore, “risk communication is a complex, dynamic and interactive process that is highly dependent on audience psychology, knowledge, skills, and capabilities” (Otto et al., 2018, p. 140). Risk communication can reduce vulnerability to NHs when it increases knowledge and understanding and influences attitudes and actions to improve the coping capacity of people (Lazrus et al., 2012; MacIntyre et al., 2019). This is why risk communication is crucial in reducing vulnerability towards hurricanes and NHs in general.

However, several components need to be considered while communicating risks. Even though the aim of risk communication is mainly thought of as informing people to reach a certain action, this cannot be achieved in most cases. This is because two conditions need to be fulfilled for this to happen. Renn (2008) states that there needs to be the ability, ergo the physical access

to information, the time to process this information and the absence of sources of distraction. Moreover, there needs to be motivation to listen to the information. This is achieved if the topic has references to a personal interest, indicates personal involvement with the issue and is linked with interesting content or a well-known source. If the message is taken up, ergo the person has the ability and motivation to listen to the communication, the process of information selection and processing takes place. However, recipients of the message often react in irrational ways, even though one awaits rational behaviour in response to the communication (Millet et al., 2020).

This is because risk communication is influenced by people's thoughts which are individual to every person based on their personal experiences in life, their culture, language, and previous knowledge. Thus, there is no tailor-made solution for risk communication, yet the risk manager responsible for communication should be aware of the fact that his/her message might be understood differently than intended and keep this in mind while preparing different variations of messaging (V. Brown et al., 2016; Lazrus et al., 2012).

4.2.1 The Judgement & Decision-Making and Mental Model Approach in Risk Communication

Due to the personal experiences that influence the perception of people towards risk communication, several approaches to understanding this influence can be found in the literature. Here two concepts that strongly influenced the research on risk and NHs are introduced. These are the Judgement and decision-making (JDM) and the mental models (MM) approach. Even though there are several more approaches, the two aforementioned are benefitting hurricane risk communication notably (Millet et al., 2020).

The JDM approach is focusing on the decision-making process, where people use heuristics to decide on probabilities and following actions. These cognitive shortcuts are beneficial when a fast decision is required, or the situation is familiar and the decision process is known (Millet et al., 2020). Kahneman and Frederick (2002) describe this form of heuristic thinking as system-1 thinking; rapid thinking which happens mostly unconsciously and with nearly no effort. The contrary is system-2 thinking, which is purposeful, slow, and deliberate.

However, through system-1 thinking biases occur, similar to the ones described for risk perception, which are regularly repeated and are studied in the literature. According to Milch et al. (2018), common biases include:

- temporal and spatial myopia, where the affected region or the time for preparation is underestimated through heuristic thinking
- objective and subjective probability estimates, which occur when an objective estimate is interpreted subjectively (e.g., hurricane track maps)

- previous storm experience, where the decision is influenced by the frequency, recentness, and personal affectedness of the previous event
- social factors, where family's and friends' advice are asked and their actions are copied
- mental models

It is important to understand these biases for risk communication because the better the common biases in heuristic thinking are known, the better the risk communication can approach them and thus improve risk communication (Gilovich et al., 2002; Milch et al., 2018; Millet et al., 2020).

The MM approach focuses less on how people make decisions but more on how their life experiences shape their overall judgement. A MM is a “cognitive structure that forms the basis of reasoning, decision making, and [...] behavior.” (N. A. Jones et al., 2011, p. 1). It is the individual filter through which people perceive their reality and is a flexible model, which is adjusted context specifically. Thus, they can be described as inconsistent representations of reality. This individual filter is created based on personal life experiences, understandings of life and personal beliefs and perceptions. (N. A. Jones et al., 2011). These MMs are as well used to interpret risk communication. With the help of their existing knowledge, people filter communication and conclude their message based on their previous experiences and react accordingly. Hence, risk communication should as well include educational material that can influence a MM and be included in the knowledge with which a message is perceived. Only through the aim of influencing MMs the perception of risk communication can be influenced (Granger Morgan et al., 2002). This can be especially beneficial because MMs of people with similar cultural backgrounds are as well similar. Hence, the consideration of MMs can benefit the understanding of the decision processes of different cultural groups and risk communication can be adjusted (N. A. Jones et al., 2011).

Finally, the goal of risk communication is to raise the level of knowledge for all stakeholders involved on the facts, issues and potential actions relevant to the risk to the extent that they can use their expertise to take decisions with their available knowledge. Again, these decisions might not be the rational ones the risk manager wishes for, due to the personal life experiences of the individual (NRC, 1989). Hence, risk communication is called a process. The communication must be reassessed and improved to get the desired result: an increase in risk perception for a specific topic to make people aware and trigger preparation behaviour and hence reduces vulnerability. Thus, risk communication can influence risk perception if one is considering that the message needs to overcome the barriers of ability and motivation first and afterwards will be assessed with heuristic thinking as well as its biases and the personal MM of each recipient. To achieve this goal there are some best practice options presented in the next chapter.

4.3 Best Practice in Risk Communication

As risk communication and its influence on risk perception is such a complex topic, this chapter will focus on several best practices for risk communication that could be identified in the literature. These best practices should be included in risk communication in Ireland.

Most importantly, the information must be prepared understandably and based on the understanding of mental models. Only then can communication be created that is in line with the audience's intuitive understanding of the topic (Fischhoff et al., 1993), especially, if local knowledge is included in risk communication and communities are empowered to be part of the communication process (MacIntyre et al., 2019). However, one should only focus on relevant knowledge that is critical to the situation and should not include unnecessary information (Fischhoff et al., 1993). Bostrom et al. (1994) found that this information is best presented in a structured format like a decision tree, an organised network based on the mental model approach, or a structured brochure (if it is for informing purposes before the actual event is happening). Further, it is important that the information is not only given out once but that there is a recurring programme of messages that is continuously repeated to make sure that the message is delivered in different formats (NRC, 1989).

Nevertheless, it should be avoided to have hierarchical communicator-audience categories, where the professional is the only expert in the dialogue and the layperson is seen as the naïve listener, as this reduces trust in the risk communication (Slovic, 1999). Additionally, risk communication that is misdirected, irrelevant or inappropriate including false alarms can be very dangerous for future events because people will lose confidence in the communication (Fischhoff et al., 1993). Hence, detailed and extensive training on how to communicate with the public is key in risk communication (Botterill & Mazur, 2004).

As the risk communication process contains several pitfalls the NOAA Office for Coastal Management (2016) created a best practice structure for risk communication which is summarised in Table 5.

Table 5: Best practice in risk communication

Recommended Practice	Detail
Have an informed plan	<ul style="list-style-type: none">• know your goal and how to achieve it before communicating risk• know your audience and meet desired media• describe protective actions and how those will benefit the audience• describe the hazard, including location and timing• disclose the source of information• provide options for further information

Continuing Table 5

Recommended Practice	Detail
Speak to audience's interest	<ul style="list-style-type: none"> • connect emotionally with audience values and concerns • give audience opportunity to be heard, understand how they interpret message → start a dialogue • become a trusted messenger • consider different social, demographic, and economic contexts
Explain the risk	<ul style="list-style-type: none"> • communicate understandably to the audience (clear + appropriate) • explain impacts, refer to past events, use stories, visuals • allow audience to share experiences (local stories are trusted)
Offer options for reducing risk	<ul style="list-style-type: none"> • offer options and guide how to achieve them • describe how options benefit audience • empower locals and communities to protect themselves • engage in emergency planning before the disaster • allow discussion of options
Work with trusted sources and the public	<ul style="list-style-type: none"> • people seek advice from public sources to verify risk • identify sources and engage with audience regularly • establish partnerships with sources of trust (also community networks) • create and share consistent information via all sources
Test messages and products + evaluate them	<ul style="list-style-type: none"> • test communication on target audience before using communication method broadly + evaluate results • have a repeating cycle of feedback and adjustment
Use multiple communication ways	<ul style="list-style-type: none"> • different audiences like to receive information differently • prepare messages in the audience's preferred format • make sure message is compatible with used medium • use multiple formats → repetition increases chance of reaching audience

Based on information from NOAA Office for Coastal Management (2016)

Especially for the last recommended practice in Table 5 media and wording are of utmost importance. It is vital to be aware of demographic and gender differences in preferred warning media. According to the study by Silver (2015), conducted in Canada, men were mostly relying on radio and newspapers to gain information while women were preferring personal communication, e.g. via phone. Elderlies were relying on TV while teenagers had their smartphones as their main source of information. Thus, several different media should be used to provide risk communication.

Through their literature review, MacIntyre et al. (2019) created an overview of the most mentioned risk communication media in scientific literature. Important were

- presentations/ workshops with experts and/or community to learn from each other
- public media like TV, radio, websites, internet in general
- education and awareness programmes

- informal social network communication
- print materials like brochures, fact sheets, newspapers
- community-based scenarios based on planned exercises to create resilience
- participatory management strategies (Participatory mapping, community-based weather data)
- SM including online applications (apps)

All these approaches should be used in coexistence to reach the preferences of all stakeholders and to provide an ongoing risk communication process.

This is also advisable in times when no direct natural hazard poses a threat. Especially in SM, regular engagement is important to build and hold the trust of the audience. In times of high risk, there is also the option to then change the everyday messaging to raise the awareness of the people to the importance of the message. This can be done by exchanging the regular weather forecaster with a well-known public person and/or placing the setting of the weather forecast in a different location, e.g., from the TV studio to the forecasting centre (Otto et al., 2018). A steady exchange between the parties involved in risk management is also key when it comes to the timing of receiving information. The news broadcast usually starts every full hour, thus the information from the forecast centre or the decisions of the risk managers on what to communicate must be received at least 20 min before the broadcast, in order to prepare the message (Morrow et al., 2015).

When it comes to wording it is important to use clear and exact terms. This does not mean ‘exact’ in scientific terms but in understandable language. Hence, the terms like low inundation should be avoided as the term “low” gives room for speculation and the risk could be underestimated. The same is for the formulation of “flood depth” compared to “flood height”. Here “height” already indicates high and rising water, while the word “depth” is more associated with lowering water or land. Special terms should thus be reserved for only severe events. For example, coastal flooding for ordinary tidal floodings but storm surge for severe coastal flood events to prevent people from getting desensitised (Morrow et al., 2015). Because of misinterpretation of windspeed and precipitation values, the NHC changed recently to impact forecasting and reduced the physical characteristics forecasting (Millet et al., 2020).

5. Methodology

To assess the objectives of this Thesis each objective is connected to a scientific method. Figure 13 shows the connection of the objectives to the methods and how methods and objectives build upon each other to achieve the general and overall objectives of this research.

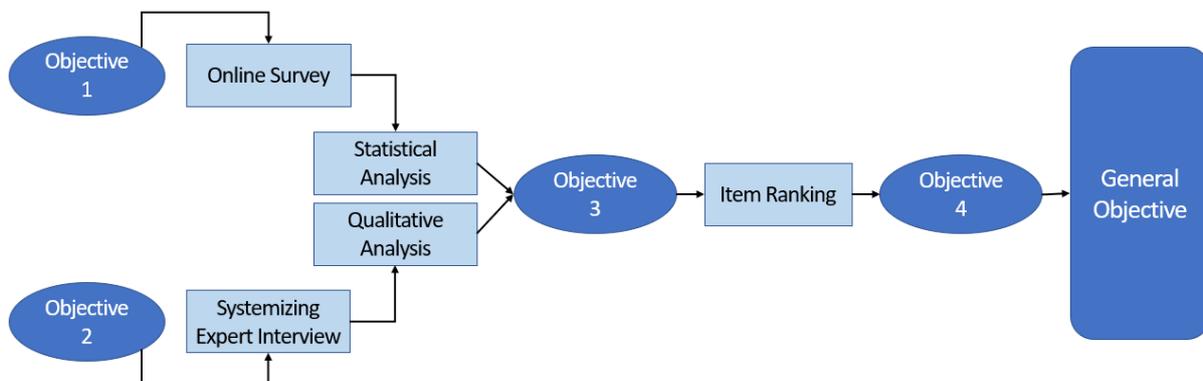


Figure 13: Scheme of objectives and their related methods

Different methods were used to achieve the different objectives. Hence, there was a standardised survey with citizens of Cork to gain information about the perception of NHs in Ireland and to assess the perception of the communication process during Ophelia (Objective 1). Furthermore, systemizing interviews with experts were conducted to obtain an overview of the risk communication structure, during Ophelia, the content of communication and its different thresholds (Objective 2). The survey as well as the interviews were analysed, and the participants were asked if they missed anything that could be improved in future events. After the analysis of the data, the results were compared and connected (Objective 3). The suggestions for improvement, which were made were collected and sent to the experts. The experts were asked to rank the suggested improvements according to their importance for future risk communication (Objective 4). In the following, each method is described in detail.

5.1. The Standardised Survey

To assess Objective 1 a standardised survey after Porst (2011) was conducted. The survey was an online survey created in Google Forms. It was distributed to the people of Cork via different local Facebook groups of the area, namely “Cork News and Events”, “Cobh sell, buy or swap” and “Kinsale Notice Board” and through the mailing system of University College Cork (UCC). These Facebook groups were used, as the most severe damage in Cork was reported from these three cities (Cork County Council, 2017) and all groups had more than 3000 members during the time of the survey. The advantage of the written survey is that it enables the participants to answer the questions anonymously and provides a safe atmosphere for giving an opinion (Aeppli et al., 2016).

The aim is to show the results in a quantifiable and statistically manageable manner. Further, it aims to assess the risk perception of people before and after Ophelia. To conclude if the perception is related to any impact of a disaster that they have experienced, questions were asked if the people were directly affected by the storm or any other hazard. Additionally, questions about risk communication were asked to see if the perception of the communication is good and to gain possible improvement suggestions for communication content and media.

Hence the survey was subdivided into four sections as shown in Table 6. The full survey is displayed in Annex 1.

Table 6: Content of citizen survey

Survey Section	Questions content
1 – Natural Hazards and their perception	Asks about the participants feeling towards NHs, if they are concerned about them or not, which is the one they fear most, as well as if they have been personally affected by any.
2 – Hurricane Ophelia	Questions the respondent about how affected they were by Ophelia and in which way they have been affected. Further, it is asked if the people were concerned about hurricanes hitting Ireland before Ophelia and if they are more concerned after the event.
3 – Risk Communication	Asks if the threat of the event, as well as behavioural advice, was given, how it was given before and after the event, and if the people felt informed. Additionally, it is asked what information they would have wished for.
4 – Personal Information	Contains demographic questions like sex, age, and place of living.

In the end, the survey was evaluated with the statistical software SPSS. A detailed description of the analysis of the data is given in chapter 5.3.1.

5.1.1 Hypotheses

After the review of the relevant literature, especially the impacts Ophelia caused in Cork and to its inhabitants as well as the literature about risk perception and risk communication the following hypotheses were formulated. The hypotheses shown below are the H_1 hypotheses. In general, the H_1 hypotheses are the formulation of the assumption that is made by the author based on the literature. The H_0 hypotheses describe the contrary of the H_1 hypotheses and are the hypotheses that will be proven or discarded through statistical analysis. However, if a H_0 hypothesis is discarded it does not automatically mean that the related H_1 hypothesis can be accepted. It only shows that the H_0 hypothesis is not true (Bortz & Döring, 2006).

1. Hurricanes are ranked higher by the people⁴ after Ophelia made landfall than they are ranked before Ophelia made landfall.
2. If people fear hurricanes in the future (value 5 or 6), they will assign the risk of hurricanes a value of 1 or 2 or 3 on the ranking scale.
3. If people were living in Cork during Ophelia happened, they will not rank the threat of hurricanes as 1 or 2 or 3 in the ranking more often than the ones that were not living in Cork during the storm.
4. People who have rated their affectedness by Ophelia ≥ 4 , rank the threat of hurricanes as 1 or 2 or 3 in the ranking more often than the ones that were less affected and rated < 4 .
5. If people assign the value 5 or 6 to the questions if they feel well informed about how to behave during Ophelia or about the threat of Ophelia, they will not add anything in the text field “what was missing”.
6. People who assign the value ≥ 4 to the question about how afraid they are of NHs affecting them, rank the risk of hurricanes as 1 or 2 or 3 more often than the ones that were less affected and rated < 4 .
7. If people rate their affectedness by Ophelia ≥ 4 , they will also state that they have been affected by a natural hazard in the past 6 years.
8. If people assign the value ≥ 4 to the question about how afraid they are of NHs affecting them, they will answer that they have been affected by a natural hazard in the past 6 years.
9. A low rating of affectedness by Ophelia correlates positively with a low rating of concern about hurricanes in Ireland in the future.
10. Participants feel more concerned about hurricanes in the future than they have been before Ophelia.

5.1.2 Layout of the survey

The survey contains closed, half-open, and open questions. The closed questions make sure that standardisable answers are obtained, while the half-open questions also provide an opportunity for the people to express their thoughts in case the standardised responses are not suitable for them as well as giving the people the feeling of more intense participation. Open questions have the advantage that the participants can express their answers in their own words without being obliged to use standardised answers (Porst, 2011). Especially at the beginning of the risk

⁴ Here and in the following hypotheses the term “people” stands for the participants of the survey which were living in Cork during the time of the survey.

perception section, there are two open questions because it is not wished to steer the participant's thoughts to any natural hazard, which could be associated as a risk.

For all closed questions in this survey where a feeling or opinion is asked⁵, the supplied categories of the answers are only named at their extreme ends. That gives the possibility to address them as interval scales, which opens the option to interpret them statistically deeper than ordinal scales. Further, it was chosen to only use scales with an even number of six as possible answers, to avoid respondents placing themselves in the middle of a scale, in case they are unsure if they can or want to answer that question as this is often the case if there is an odd number of possible answers (Porst, 2011).

On purpose, no information about Hurricane Ophelia was given at the beginning of the survey to avoid steering the thoughts of the participants to that event and thus get a real picture of NHs they feel threatened by. Hurricanes were first mentioned only in question five, where an ordinal ranking after Borda (1781) and Kendall (1975) was included in the survey. In an ordinal ranking, the participant must place a discrete value on any option. It is not allowed to assign two or more options to the same rank. (Mendoza et al., 1999).

After the creation of the survey, a pre-test was done. The online survey was sent to 30 people. 15 people answered the pre-test and sent their results and five other people only sent comments without providing the answers to the poll. Following, some minor adjustments in spelling were made, as well as one answer category was added to one question. The incoming answers were all in line with the expected results, so people understood the question form and what they were supposed to do.

This questionnaire fulfils the quality criteria of objectivity, validity, and reliability, which will be justified in the following. A questionnaire is considered objective if different users arrive at the same results as other participating persons, i.e., an objective questionnaire is independent of the concrete user (Bortz & Döring, 2006). Through the pre-test and its successful answers, objectivity is given. Moreover, through the standardised characteristics of the survey, every participant is asked the same questions, with the same wording and the same order. Additionally, the survey questionnaire is described in detail and a full version can be found in Annex 1 which makes it transparent.

Validity is supposed to show that the survey is exactly measuring what it is supposed to measure (Bortz & Döring, 2006). This is given in this survey because each section (Natural hazards and their perception, Hurricane Ophelia, and Risk communication) contains at least four questions that gave successful answers in the pre-test. Further, a test is legitimate if hypotheses can be

⁵ In the following referred to as “rating questions”

formed from the construct and based on the literature which can be assessed and validated by the results (Bortz & Döring, 2006). The validation through results was done in chapter 6.

The reliability shows the precision of the survey and if it can be replicated (Bortz & Döring, 2006). This is given as the questions were standardised for every person, appear all in the same order and the possible answer categories were not randomized in sequence. Further, there was no question where people would feel obliged to answer under social pressure, as the participants were able to complete the survey on their own, through its online character and through the fact that the survey was completely anonymous. Moreover, the interpretation of the results is exactly described in this thesis, thus, it is replicable.

5.2. The Systemizing Expert Interview

To gain information from the different institutions, like local governments, ministries, warning agencies and stakeholders that were involved with the management of Ophelia, interviews were conducted. The interviews with the experts aimed to show the risk communication chain, the content of the risk communication and the media the risk was communicated with. Furthermore, they gained information about different thresholds that trigger different communication details. Most important they obtained information about the lessons learned in terms of risk communication after Ophelia happened. Thus, the method of systemizing expert interviews as described in Bogner et al. (2014), was performed for all interviewees who are not in the main function of affected citizens but in the role of an expert⁶. Here, experts are people that work in emergency management, who deal with the management of NHs and who had their expert position already during Ophelia. These interviews aimed to generate knowledge from experts. This information was then analysed with a qualitative interview analysis. Therefore, a partly structured questionnaire was created, as per usual for this kind of interview. The interview questionnaire structured not only the thematic context and the interview itself but also the analyses of the information gained (Bogner et al., 2014). This type of questionnaire opens the possibility to create a normal conversation situation and allows for further questions which are not written down in the questionnaire yet, in case it is needed, or new aspects come up, which are relevant to the research. The questionnaire's purpose was to create an atmosphere where the interviewee can talk freely and explain all information and details that seem relevant to him/her. The full questionnaire can be found in Annex 3.

⁶ Experts are counted as experts, even though there might have been privately affected by Ophelia

5.2.1 How to choose the Experts

The choice of the experts was based on suggestions made by Dr Kieran Hickey from the geography department of UCC. He kindly suggested several institutions involved in risk management during Ophelia. Of this list, several institutions were asked for interview appointments but also institutions that were not mentioned on the list but appeared relevant for this research. The institutions were contacted via e-mail and phone. Sometimes it was possible to write to specific persons directly but sometimes the queries were only sent to the general contact address of the institution together with the request to forward the mail to a person that is suitable for an interview.

In the end, eight representatives could be interviewed from eight different institutions. Interviews were held with a representative of Met Éireann, ESB, ESB Networks (ESBN), Civil Defence (CD) County Cork, Civil Defence Cork City, Fire Brigade Cork City, Health Service Executive, and Cork City Council.

Before the start of every interview, the research aim of this thesis was explained, together with the objectives of this work. Further, the interviewee was asked if he/she agrees to be mentioned by full name and position, only position or only as a representative of the institution he/she was working for in this thesis. Here three people wished not to be named in their position or with their names. In the end, the interviews were conducted with:

1. Civil Defence Officer County Cork South, John Kearney (in person)
2. A representative of the Cork City Fire Department and a representative of Cork City Civil Defence (in person)
3. Director of Operations, Cork City Council, David Joyce (in person)
4. Head of Forecasting Division of Met Éireann, Evelyn Cusack (online)
5. Senior Press Officer ESB, Paul Hand (online)
6. Emergency Management Officer HSE South, Cian O'Brien (in person)
7. A representative of ESB Networks (online)

With permission of the interviewees, the interviews were all recorded. The audio data was summarised and not exactly transcribed. Hereby the wording of full sentences was kept, however, half sentences or started sentences that were afterwards explained differently in other words were summarised. To ease the analysis, information that did not belong under the specific question and had a different content, more appropriate as the answer to another question, was moved there where the answer would have been more suitable.

5.3 Data Analysis

5.3.1 Evaluation of the Survey

The survey was online for one month, as it was not possible to have it online longer due to time constraints. Participation was voluntary. The participants are part of a systemised random sample in form of a cluster sampling. The publication of the survey in Facebook groups and via the e-mail system of UCC resulted in a clustering of the available statistical population. People must have a Facebook account, an internet connection and a device to access the internet. Still, a clustering sample is categorised as a random sample which makes it possible to generalise the results with inductive statistics onto the statistical population (Blasius & Baur, 2014), which in this case is the population of Cork.

The sample for this survey are all people currently living in Cork, as the research of this thesis focuses on the perception of the people living in this Irish county. After the survey period, a total of 102 responses were obtained. However, to evaluate the survey data the data was first cleaned. Hence, the sample was reduced by the people that did not live in Cork during the time of the survey, as this work focuses on the risk perception and communication of the people in Cork. The people currently living in other Counties were 12 in total. One person only stated that she was living in “Blackrock” however, there is more than one town in Ireland called “Blackrock”. Even though it can be assumed that the suburb of Cork is meant here, as the survey was published in Facebook groups concerning Cork and its surroundings, it can not be said with certainty. Hence, this response needed to be excluded, as well. Resulting, 90 answers remained. Afterwards, the data was inserted in SPSS and checked for completeness, where missing values are indicated with the shortage “-99”.

Next, the intra-individual response variability was calculated. This test is done to see if respondents rushed through the questionnaire by giving the same answer too often (Dunn et al., 2018). This was the case for one person who was excluded afterwards. In the end, 89 responses were used for statistical calculations.

Of the remaining 89 participants, eight participants only ranked one natural hazard in the first ranking and of these, three stated that they would have ranked differently prior to Ophelia and then ranked the same as before. These values were considered non-reliable and thus were signed as missing values. The same happened to contrary statements within a question itself (e.g., “I was informed via Radio” and “I was not informed” within the same question). Further, answers, where “other” was chosen but “other” was not explained afterwards were also marked as missing values. Here only the answer “other” was excluded not the whole answer to the question. For example in the ranking or in questions where more than one answer was allowed, all answers remained valid and only “other” was marked as missing if this was not elaborated further.

In SPSS the data was assigned the correct scale (nominal, ordinal, interval/metric) and the answer possibilities of the questions where participants were supposed to rate their answers were assigned the values one to six, where a complete agreement was rated as a six and complete disagreement was rated as a one. The possible categories of yes and no questions, as well as age and gender groups, were also assigned numerical values. Where “No” = 0; “Yes” = 1; “Female” = 1; “Male” = 2; “Diverse” = 3 and so on. Then the absolute and relative frequencies of the characteristics “gender” and “age” as well as the current place of living were first determined to describe the sample. Subsequently, the content of the survey was evaluated.

The content of the survey was first generally evaluated via descriptive statistics under consideration of the scale level of each question. As mentioned previously there are two rankings, which are ordinal scales as well as the questions on how people were affected and how they received information before and after Ophelia made landfall. Nominal scales are the questions where a yes or no answer is required, as well as the question about the age category and gender. The questions with open text are not statistical scales and were evaluated qualitatively. The previously mentioned rating scales which are interval scales allow for the calculation of the arithmetic mean in case these variables are normally distributed. The normal distribution of the data is desirable because many inferential statistical procedures require normally distributed values (Bortz & Döring, 2006) and thus if there is no normal distribution of the data, one must switch to a non-parametric procedure (Steiner & Benesch, 2018). Since we are dealing with a large sample (significantly more than 30 study objects) and the requirement for a normal distribution is therefore met (Bortz & Döring, 2006), it is sufficient to use the graphical methods of the QQ plot to assess the presence of a normal distribution. The normal distribution is as well of importance for the Pearson correlation which is used to accept or deny hypothesis nine. See more details about the Pearson correlation below.

To answer the different hypotheses different methods were used. As most of the hypotheses are based on one interval and one ordinal scale it was not possible to calculate correlations after Pearson for these hypotheses. Thus, most of the hypotheses were answered with specifically calculated frequencies. Only hypotheses, 9 and 10 were evaluated differently. A scheme for the evaluation of all hypotheses is shown in Figure 14. The full list of the hypotheses was given in chapter 5.1.1.

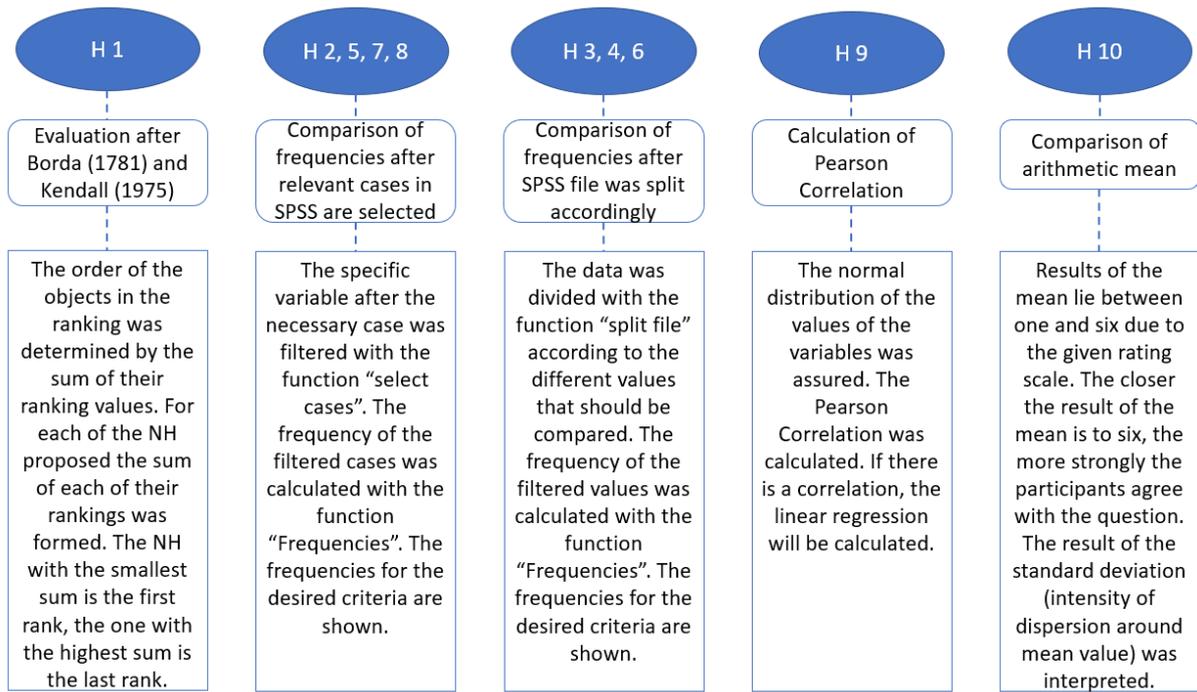


Figure 14: Scheme of hypotheses evaluation
Source: Figure created by author

If the data, which is used to evaluate hypothesis 9, has an interval scale and a normal distribution, which is assumed at this point, the Pearson correlation is a useful tool to assess if there is a correlation between the data (Steiner & Benesch, 2018). The correlation can be negative or positive and lies between minus one and one. The calculated correlation coefficients are then interpreted after Cohen (1988) as follows (equal for the positive and negative values of the correlation): If the correlation coefficient is

- $< 0.1 \rightarrow$ no correlation.
- ≥ 0.1 and $< 0.3 \rightarrow$ low correlation
- ≥ 0.3 and $< 0.5 \rightarrow$ medium correlation
- $0.5 \rightarrow$ strong correlation.

If the results show that there is a correlation between the degree to which Ophelia affects people and their fear of future hurricanes in Ireland, a linear regression analysis is carried out to further test the correlation. Linear regression analysis makes it possible to test the relationship between an independent and a dependent variable (Steiner & Benesch, 2018), and thus to determine the influence of the independent variable on the dependent variable. Here, the degree of concern is to describe the influence on the perception of fear of future hurricanes in Ireland. In the evaluation, it is first checked whether all variables were included in the respective model and the significance of the Anova is considered for the respective models. In addition to the R-squares and the corrected R-squares of the models, the regression coefficients and the corrected correlation coefficients are then considered. The R-squares are to be interpreted in such a way that

the following applies: if the amount of R-squares is at least 0.02, the model has a weak variance explanation, if it is at least 0.13, the model has a medium variance explanation and if the amount is at least 0.26, the model has a high variance explanation (Cohen, 1988).

5.3.2 Qualitative Content Analysis

For the expert interview analyses the qualitative research program MAXQDA was used. Qualitative Data Analysis software is particularly useful for assessment methods in which the development of categories is important, such as the "informational" evaluation by way of content analysis that is employed for the analysis of expert interviews (Kuckartz, 2018). All interview transcriptions were uploaded into the program and the texts were coded. Following Mayring (2015), the next step was the definition of the units of analysis. These consist of the coding unit, the context unit, and the evaluation unit. The coding unit describes the smallest text unit that can be assigned to a category, the context unit describes the largest possible text unit that may be assigned to a category, and the evaluation unit determines the order in which the text sections are evaluated. The coding unit was set here as a single word as this can describe, for example, communication media used, the context unit was set as a whole paragraph of an interview and the evaluation unit was set as the order in which the interviews were conducted from the earliest date to the latest. The rules placed here were applied to all interviews.

For the deeper analysis codes were created deductively beforehand, based on the interview questionnaire. These codes were:

1. Risk Communication chain
 - a. Intra-Agency
 - b. Inter-Agency
 - c. Public
2. Risk Communication Content
 - a. Intra-Agency
 - b. Inter-Agency
 - c. Public
3. Thresholds for Communication
4. Communication Media
 - a. Before
 - b. During
 - c. After
5. Changes in Communication Chain
 - a. Before
 - b. During
 - c. After
6. Changes in Communication Content
 - a. Before
 - b. During
 - c. After
7. Changes in Thresholds
 - a. Before
 - b. During
 - c. After
8. Improvement Suggestions

During the coding five more codes were created based on the data mentioned in the interviews:

9. General lessons learned
10. Challenges
11. Other natural hazards
12. Characteristics that caused impact
13. Info about LCC (Local Coordination Centre)

For code category seven, subcodes were created before the start of the coding but no text passages were assigned to these code categories, thus these categories were deleted after the coding was completed. A complete list of code categories and their set content is displayed in the Tables in Annex 4. After a new creation of a code category, all the documents were analysed again to see if the new categories influenced the already completed coding of the interview summary.

To ensure intersubjective comprehensibility the categories were defined after their creation. This requires a description of the content of the category, a description of when the category is applied and an example of the application, so-called anchor examples (in the form of a text citation). During the first processing of a part of the material, the categories are checked for the accuracy of their delimitation and were revised if necessary (Mayring, 2015).

The analysis of the categories followed the scheme of content-structuring qualitative content analysis according to Kuckartz (2018). The focus of this content analysis was on the topics and sub-topics of the interviews. Since the data material at hand was exclusively examined qualitatively, only the following evaluation methods were used:

1. category-based evaluation along with a main category.
2. analysis of the correlations between the sub-categories of a main category
3. analysis of the correlations between categories

The first method serves to present the results of the main categories. It shows which statements were made, but also which statements were not made or only rarely made. Method two analyses categories within a main category as well as subcategories between the main categories. Within a main category, correlations can be found between the subcategories and possibly patterns can be identified. The third method examines the relationship between the main categories. This can be the relationship between two or more categories.

5.3.3 Assessing the Improvement Potential

The improvement potential was assessed after all interviews are conducted and the survey was closed. Out of the conducted interviews, the improvements suggested by the interviewees were extracted and written down. All the suggestions were inserted into a poll, and this was sent to the interview partners via e-mail. Again an ordinal ranking after Borda (1781) and Kendall (1975) was chosen. The ranking happened from 1 -most important- to 14 being the least important improvement.

Before the start of the research, it was set that the ranking possibilities must not be too multiple. Not more than 15 items were preferred. If this number would have been exceeded the suggestions would have been categorised and the categories would have been ranked by the participants (Qualtrics, 2021). After completion, the ranking of the suggestions was analysed, and improvement suggestions were based on the ranking.

Nowadays, ranking is one of many Multi-Criteria Analysis (MCA) tools used to make scientific-based decision-making (Geneletti, 2014; Mendoza et al., 1999). “MCA describes any structured approach used to determine overall preferences among alternative options” (United Nations Framework Convention on Climate Change [UNFCCC], 2005, p. 47). MCA is an overarching term for several tools that support decision-making with the help of comparing, ranking, classification, and choice and thus finding the best suitable options out of many heterogenic variables (European Commission, 2021; Geneletti, 2014; UNFCCC, 2005). Hence, it is mostly applied when one most favoured alternative must be identified, or when it is necessary to rank or shortlist potential alternatives in public decision-making. Strengths of the methods are its openness to a manifold of opinions and values, its ability to incorporate qualitative factors and its promotion of stakeholder participation. However, depending on the method chosen it can be time-consuming and somehow complex, stakeholders can be reserved to participate, and the choice of stakeholder and the timing of the MCA can influence the results (Geneletti, 2014). However, by choosing the ordinal ranking the first limitation was avoided in this work due to its simplicity. Moreover, as the stakeholders were already open to participating in interviews, it was assumed that they will not be reluctant in sharing their opinion on the matter.

Ranking is the activity where a stakeholder assigns, with their individually perceived importance, a rank to an option. As mentioned before in the ordinal ranking, the stakeholder must place a discrete value on any option and is not allowed to assign two or more options to the same rank (Mendoza et al., 1999). Due to this premise, the Borda-Kendall ordinal ranking method was chosen. According to Cook and Seiford (1982) and Lansdowne (1996), this method performs well if there are no tied rankings, which are eliminated due to the discrete values that should be assigned to each option. Further, it is very simple. Hence, it was chosen because of

its simplicity and because this work only focuses on the importance of the suggestions and not their trade-offs.

The evaluation of the rank was done as described in Figure 14 in chapter 5.3.1 for hypothesis one. The sum of the rankings assigned by the experts was calculated for each improvement suggestion. In the end, the smallest sum indicates rank one, and the highest sum is the last rank.

After the qualitative analysis, several improvement suggestions were found. However, not all of them were based on risk communication or could be included in the risk communication chain, content, or media. Thus, in the ranking, 14 improvement suggestions were given to the experts which can be found in chapter 7.5.

These were ranked by six of the interview participants, as two of them (Evelyn Cusack and Paul Hand) were excluded from the ranking as they are risk managers on the national level and do not focus on Cork. However, one representative of Cork County Council was included, who was not available for an interview but was generally interested in the research and the improvement suggestions the other interviewees gave. Thus, a total of seven people were asked to rank the improvement suggestions for risk communication. In the end, six of them participated in the ranking.

6. Results of the Survey

This chapter describes the results of the quantitative analysis of the survey and their interpretation. The first subchapter will describe some characteristics of the sample, the next subchapter will focus on the general results and observations that were not asked in the specific hypothesis, and the following subchapters will show the results of the calculations to accept or neglect the hypothesis.

6.1 Survey Sample

The gender distribution of the sample of 89 includes 65% female and 34% male participants as well as 1% who stated themselves as diverse, however, this option is often used by people who do not want to state their sex, especially if there is no option like “would rather not say”. Figure 15 shows that the age distribution of the participants is relatively equal, especially for the groups 16-30, 31-45, and 46-60. Persons with an age between 61-75 are a little less represented than the ones mentioned before. Only the age group older than 75 is not very much considered, as well as the age group younger than or at the age of 15. However, the latter would have been at the age of nine or younger at the time Ophelia happened and thus can be seen as less relevant for the stated questions about Ophelia, as the children may not have been the ones caring about information that much. This would have been the role of the parents.

Of the sample of 89 people, most of the people were staying in Cork (88.8%) during Ophelia. Only a few were staying in Co. Galway (3.4%), Co. Limerick (1.1%), Co. Clare (2.2%), Co. Dublin (1.1%), Co. Kerry (1.1%) or have not been in the country at all during the event (2.2%).

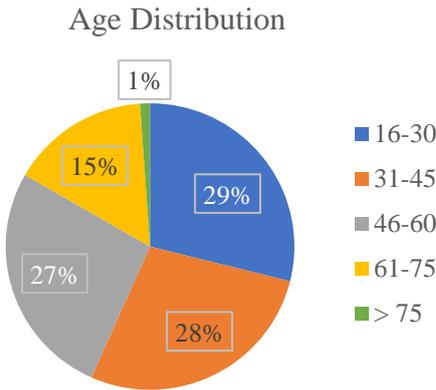


Figure 15: Age distribution of the survey participants. Graphic created by author. Note: the age group ≤ 15 was not included in the graphic as no one picked this age category

6.2 General Results

This chapter describes the general results of the survey. Here mainly mode, median, mean and frequencies (absolute and relative) are shown. The questions in Table 7 are all interval scales and the arithmetic mean could be calculated.

All in all, the results of the first question show that the people in Cork are not overly concerned about being affected by NHs, as the arithmetic mean of the first survey question “How afraid are you of natural hazards affecting you?” is only at 2.58 out of six possible categories, which can be seen in Table 7. However, the standard deviation is relatively high which indicates a broad variety of answers given. This is the case, as most of the people rated their fear of NHs with two (33.7%) as the mode indicates, followed by four and one (“I am not afraid”) which are both rated by 21.3% of the participants (Annex 2, Table 15).

Table 7: Descriptive statistics of the survey rating questions

	Mean	Median	Mode	Std. Deviation
Fear of being affected by NHs	2.58	2.0	2	1.232
Affectedness through Ophelia	3.03	3.00	2, 4	1.393
Information satisfaction about threats of Ophelia	4.27	5.00	5	1.444
Information satisfaction about behaviour during Ophelia	4.64	5.00	5	1.236

When people were asked, if they have been personally affected by NHs in the past six years, 61 participants/ 68.5% answered “no”, and 28/ 31.5% answered “yes”.

The open question for people who stated that they have been affected, “What is the natural hazard that first came to your mind that you have been affected by?” was answered mostly with “storm” followed by “hurricanes” and “flooding”. Three people even named Hurricane Ophelia explicitly. However, people also mentioned snow and ice as a natural hazard they have been affected by (Annex 2, Table 17). Snow was also a hazard that was often mentioned in the follow-up question “Which natural hazard, that occurred to you, was the most devastating one in your opinion?” it was mentioned five times, and only “storm” and “hurricanes” were mentioned more often with seven and six, respectively (Annex 2, Table 18).

Interestingly, when it comes to the question “How affected were you by Hurricane Ophelia that hit Ireland in October 2017?” only 14 people stated that they have not been affected. The average rating for this question is 3.03 however the standard deviation is again quite high, with 1.393 (Table 7). The same number of people answered this question with the value two as with four (23.6%) and 20.2% answered with three (Annex 2, Table 15). So, it can be assumed that the people experienced minor to slight damage. Nevertheless, the most chosen statement of how

people were affected was “Prolonged disruption of power supply” followed by “damage to property”, “Prolonged disruption of internet connection” and “I was not affected”, with an absolute and relative valid frequency of 39/ 20.6%, 33/ 17.5%, 32/ 16.7%, and 26/ 13.8%, respectively (Annex 2, Table 19). As participants were allowed to choose more than one medium of the suggested the absolute number is exceeding the total number of 89 participants. Intriguingly 26 people state here that they have not been affected.

Table 7 illustrates that the question “How informed did you feel about the threats of Hurricane Ophelia?” has an arithmetic mean of 4.27 with a standard deviation of 1.444. The question “How informed did you feel about how to behave during Hurricane Ophelia?” has an arithmetic mean of 4.64 and a standard deviation of 1.236. The mode and median lie at five for both questions. This shows that the participants of the survey feel well informed about the threat of Ophelia and how to behave during the storm, even though the standard deviation is still quite high. This is also shown by the frequencies of ratings given. Most people rated a five (32/ 36.0%) for information satisfaction about the threats of Ophelia and 17/ 19.1% rated their satisfaction as four or six. For the question about information satisfaction on how to behave during Ophelia, most participants rated a five, followed by six and four with 32/ 36.0%, 25/28.1%, and 13/ 14.6%, respectively (Annex 2, Table 15).

The top three media used before Ophelia made landfall were TV (69/ 23.3%), radio (46/ 15.5%), and SM (39/ 13.2%) (Annex 2, Table 20). Again, participants were allowed to choose more than one medium of the suggested, thus, the absolute number is exceeding the total number of 89 participants. The media used did not change after Ophelia made landfall. However, the amount of people using TV is decreasing to a frequency of 59/ 22.3% and radio and SM are slightly increasing with 47/ 17.9% and 43/16.4% respectively. Only a few people chose “Other” to describe their source of information (Annex 2, Table 21). Here they mainly mentioned text messages from work/ university before the landfall of Ophelia and text messages and own observation of damage in the neighbourhood after Ophelia (Annex 2, Table 22). The least used media were the printed newspapers with 11/ 3.7% before the landfall of Ophelia (Annex 2, Table 20) and 5/ 1.9% after landfall (Annex 2, Table 21).

6.3 Hypothesis 1 – higher rank for hurricanes after Ophelia

This chapter will prove or decline hypothesis one by showing and interpreting the frequencies of the ranking of NHs in Ireland before and after Ophelia.

Table 8 shows the sum of all ranking values of the two rankings and the final rank to a natural hazard. The “ranking after Ophelia” shows the ranking of the people past the event and the “ranking before Ophelia” shows the values of how people would have ranked the NHs before they experienced Ophelia.

Table 8: Sum of all ranking values and their assigned final rank before and after Ophelia

	Ranking after Ophelia		Ranking before Ophelia	
	Sum of all ranking values	Rank	Sum of all ranking values	Rank
River Flooding	293	2	83	2
Drought	401	6	119	5
Heat Wave	382	5	101	3
Storm	266	1	82	1
Hurricane	349	3	136	8
Storm Surge	373	4	106	4
Wildfire	453	8	135	7
Landslide	444	7	125	6

The ranking could be interpreted with the help of the cumulated assigned values for each NH, without considering “Other” as this field was not obligatory and thus does not give a correct picture of the accumulated assigned values. As a result, we get the ranking as shown below:

1. Storm
2. River Flooding
3. Hurricane
4. Storm Surge
5. Heat Wave
6. Drought
7. Landslide
8. Wildfire

Interestingly, the ranking changes drastically if people state that they would have ranked the hazards differently prior to Ophelia. There is not much difference in the ranking of the accumulated values for the first two places. However, considering the cumulated ranking values of the last places (leaving “Other” out again) we get the following ranking:

1. Storm
2. River Flooding
3. Heat Wave
4. Storm Surge
5. Drought
6. Landslide
7. Wildfire
8. Hurricane

This shows a clear difference in rankings if we compare the answers of the people after Ophelia happened and the answer, they state they would have given before Ophelia made landfall in

2017. Hence, we can decline the H_0 hypothesis. It is not the case that people rank hurricanes in a lower place after Ophelia made landfall than they did before. The ranking shows us that the sample ranked hurricanes in a much higher rank (rank 3) after they experienced Ophelia than they would have done before they experienced the 2017 PTC (rank 8).

To not forget the NHs that were mentioned in case a participant ranked “Other” a short description of the mentioned NHs can be found in Annex 2, Table 16. Only 17 people stated something in the field “other”. Here one person stated that she was not thinking of anything but thought she needed to rank it. Thus, 16 valid answers were given. The most mentioned hazards here were tsunamis (4x), followed by diseases (3x).

6.4 Hypothesis 2 – future fear of hurricanes leads to higher rank

36 people stated that they fear hurricanes in the future with a value of five and six. Of these people, the frequency of the ranking for hurricanes is calculated and can be seen in Table 9. In the following Tables F indicates “frequency”, V% stands for “Valid percentage” and C% refers to “Cumulated percentage”.

However, only a cumulated 48.5% of people who fear hurricanes in Ireland in the future ranked hurricanes under the first three hazards in the ranking. This is less than half of them. Thus, it can be said that the H_0 hypothesis is proofed and can be accepted. People who fear hurricanes in Ireland in the future do not necessarily rank them under the first three hazards they feel threatened by most. Still, nearly 2/3 of the people who fear NHs in the future would rank hurricanes under the first four hazards they feel threatened by most.

Table 9: Ranking distribution for hurricanes of people who fear hurricanes in the future

Valid	Hurricane		
	F	V%	C%
1	7	21.2	21.2
2	6	18.2	39.4
3	3	9.1	48.5
4	5	15.2	63.6
5	2	6.1	69.7
6	5	15.2	84.8
7	2	6.1	90.9
8	2	6.1	97.0
9	1	3.0	100.0
Total	33	100.0	
Missing			
-99	3		
Total	36		

6.5 Hypothesis 3 – residents of Cork rank hurricanes lower than non-residents

For the assessment, the data was split into people living in Cork during landfall and people living outside of Cork during landfall. People were living in Co. Galway, Co. Limerick, Co. Clare, Co. Dublin, Co. Kerry or had not been in Ireland during the storm.

The results are displayed in Table 10. Of the people living in Cork while Ophelia made landfall only a cumulated 40% ranked hurricanes under their first three NHs, they feel threatened by most. This is again not half of them and this time the cumulative share increases only to slightly more than half of the people living in Cork during the storm who ranked hurricanes under the first four. In comparison 50% of the people not living in Cork, but in another county, ranked hurricanes under the first three places.

Hence the H_0 hypothesis of hypothesis three can be denied. The people who experienced Ophelia in Cork do not rank hurricanes higher than people that were not living in Cork during Ophelia. Moreover, it seems to be the other way around. However, one must notice that only 10 people in total were not living in Cork during the event but 79 were living in the county.

Table 10: Ranking distribution for hurricanes of people living in Cork or another County while Ophelia made landfall

County of stay during Ophelia	Hurricane			
	Valid	F	V%	C%
Cork	1	11	15.7	15.7
	2	11	15.7	31.4
	3	6	8.6	40.0
	4	9	12.9	52.9
	5	5	7.1	60.0
	6	10	14.3	74.3
	7	6	8.6	82.9
	8	10	14.3	97.1
	9	2	2.9	100.0
	Total	70	100.0	
	Missing			
	-99	9		
	Total	79		
Other County	Valid	F	V%	C%
	1	1	12.5	12.5
	3	3	37.5	50.0
	4	2	25.0	75.0
	6	1	12.5	87.5
	7	1	12.5	100.0
	Total	8	100.0	
	Missing			
	-99	2		
	Total	10		

6.6 Hypothesis 4 – affected people rank hurricanes higher than non-affected

Table 11 shows the results of the frequency calculation. A cumulative 37.2% of the people that feel only slightly affected or have not been affected at all ranked hurricanes as the first three hazards they fear most. In comparison 45.7% of people who feel more severely affected ranked hurricanes under the first three hazards that they feel threatened by most. Hence, the H_0 hypothesis can be declined, as more people who feel severely affected by Ophelia ranked the natural hazard “hurricane” under their top three NHs they fear.

Table 11: Ranking distribution for hurricanes of people being slightly or not affected and people being more severely affected

Affectedness by Ophelia		Hurricane		
		F	V%	C%
all	Missing			
	-99	1		
≤ 3	Valid			
	1	4	9.3	9.3
	2	5	11.6	20.9
	3	7	16.3	37.2
	4	5	11.6	48.8
	5	3	7.0	55.8
	6	6	14.0	69.8
	7	6	14.0	83.7
	8	5	11.6	95.3
	9	2	4.7	100.0
	Total	43	100.0	
	Missing			
	-99	10		
	Total	53		
≥ 4	Valid	F	V%	C%
	1	8	22.9	22.9
	2	6	17.1	40.0
	3	2	5.7	45.7
	4	6	17.1	62.9
	5	2	5.7	68.6
	6	5	14.3	82.9
	7	1	2.9	85.7
	8	5	14.3	100.0
	Total	35	100.0	

6.7 Hypothesis 5 – people feeling informed about Ophelia do not suggest improvements in communication

As already described in chapter 6.2, in general people feel very satisfied with the information they received about the threat of Ophelia and how to behave during the storm as the mean in Table 7 shows. The fact that 49 and 57 people rated the information satisfaction about the risks of Ophelia and the information satisfaction about how to behave during Ophelia with a five or six respectively supports this. However, some of the people with this rating in satisfaction were still wishing for additional information. For both questions, five people would still add something in this open text field. Thus, the H_0 hypothesis can be accepted. Even though, people felt well informed they wished for other information that they thought was missing.

Even though only a few people wrote down information that they would have wished to receive additionally, a short overview will be given here about what information people wished for in general. The following statements are collected from all people, not only the people who were satisfied with the information. A full list of their statements is in Annex 2, Table 23.

Participants mainly wished for information about “essential services” and “assistance” this was specified as information on what to do in case the house gets destroyed, where to go then, how to prepare and protect and what damage is expected locally. Further information was wished about how to behave in the case water supply is not available and when power is restored. One participant would have liked to know why the storm is different from a “normal ‘bad’ winter storm” and one person would have liked to know about the mild temperatures.

6.8 Hypothesis 6 – people fearing NHs rank hurricanes higher than people fearing them less

Table 12 shows that only 35.7% of people who are not very much afraid of NHs (≤ 3) ranked hurricanes under the top three NHs they feel threatened by most. In comparison, 54.5% of the people who feel afraid about NHs affecting them (≥ 4) ranked hurricanes under the first three NHs they feel afraid of most. Thus, the H_0 hypothesis can be declined as it is not the case that people who are less afraid of NHs affecting them rank hurricanes more often under their top three NHs they are afraid of than people who are concerned about NHs affecting them. It is indeed the other way around. People who are afraid of NHs rank hurricanes under their top three more often.

Table 12: Ranking distribution for hurricanes of people who are afraid and who are not afraid of NHs affecting them

Fear of being affected by NHs	Hurricane			
	Valid	F	V%	C%
≤ 3	1	9	16.1	16.1
	2	6	10.7	26.8
	3	5	8.9	35.7
	4	8	14.3	50.0
	5	4	7.1	57.1
	6	7	12.5	69.6
	7	7	12.5	82.1
	8	8	14.3	96.4
	9	2	3.6	100.0
	Total	56	100.0	
	Missing			
	-99	8		
	Total	64		
≥ 4	Valid	F	V%	C%
	1	3	13.6	13.6
	2	5	22.7	36.4
	3	4	18.2	54.5
	4	3	13.6	68.2
	5	1	4.5	72.7
	6	4	18.2	90.0
	8	7	9.1	100.0
	Total	22	100.0	
	Missing			
-99	3			
Total	25			

6.9 Hypothesis 7 – people affected by Ophelia have been affected by NHs in the last six years

35 people stated that they were affected by Ophelia with a value of four or higher and all these people answered the question if they have been affected by a natural hazard in the past six years, ergo there are no missing values. It is assumed that people who state that they are affected by Ophelia quite severely (≥ 4) will also state that they have been affected in the last six years. At least that would be a consistent statement. However, Figure 16 shows that no consistency exists between the two questions. There is a nearly equal distribution of answers of this selection of people if they were affected by a natural hazard in the past six years or not. Thus, the H_0 hypothesis needs to be discarded because it is not the case that the people who were more severely affected all state that they have not been affected. Still, it can also not be assumed that it is the

other way round because of the quite equal distribution between people who state they have been affected or have not been affected by NHs in the past six years.

Affectedness by NHs in the past six years of people who have been severely affected by Ophelia

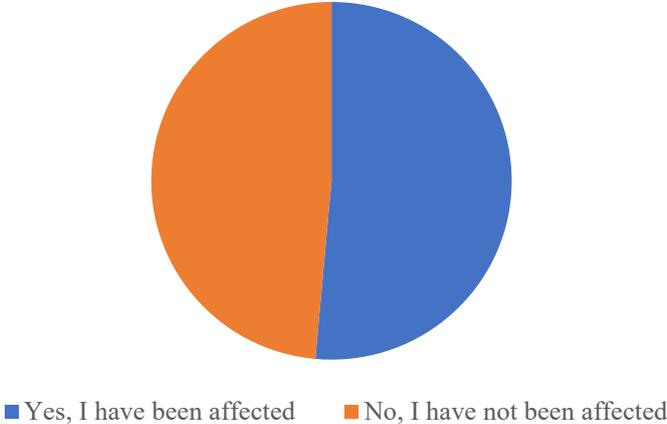


Figure 16: Answers of people more severely affected by Ophelia to their affectedness by NHs in the past six years

6.10 Hypothesis 8 – people fearing NHs have been affected by them in the last six years

A total of 25 participants rated the question if they are afraid of NHs affecting them with a value ≥ 4 . Of this sample, 68% stated that they have not been affected by a natural hazard in the past six years and 32% state that they have been affected as shown in Figure 17. Even though most of the people state that they have not been affected by a natural hazard in the past six years the H_0 hypothesis cannot be accepted, as not all the people stated that they were not affected in the past six years.

Affectedness by NHs in the past six years of people who fear NHs

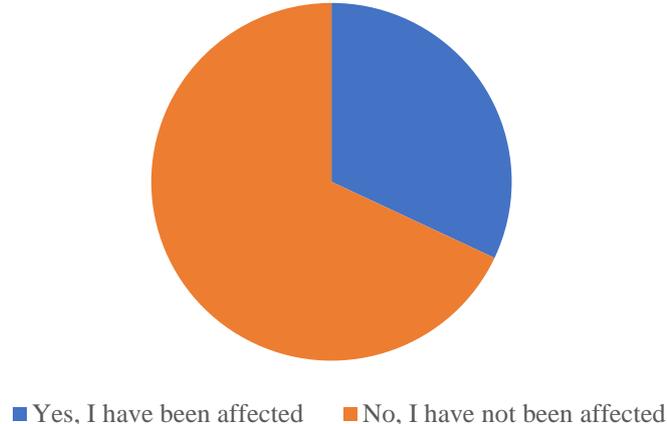


Figure 17: Answers of people afraid of being affected by NHs to their affectedness by them in the past six years

6.11 Hypothesis 9 – positive correlation between affectedness and future concern about hurricanes

As already mentioned in the methodology chapter 5.3.1, for the assessment of this hypothesis it is necessary to ensure the normal distribution of the data of the interval scales before the correlation can be calculated after Pearson. Hence, QQ plots were calculated to show the results of the normal distribution. The QQ plots are a valid tool, as the sample size well exceeds the statistical relevance of 30 participants.

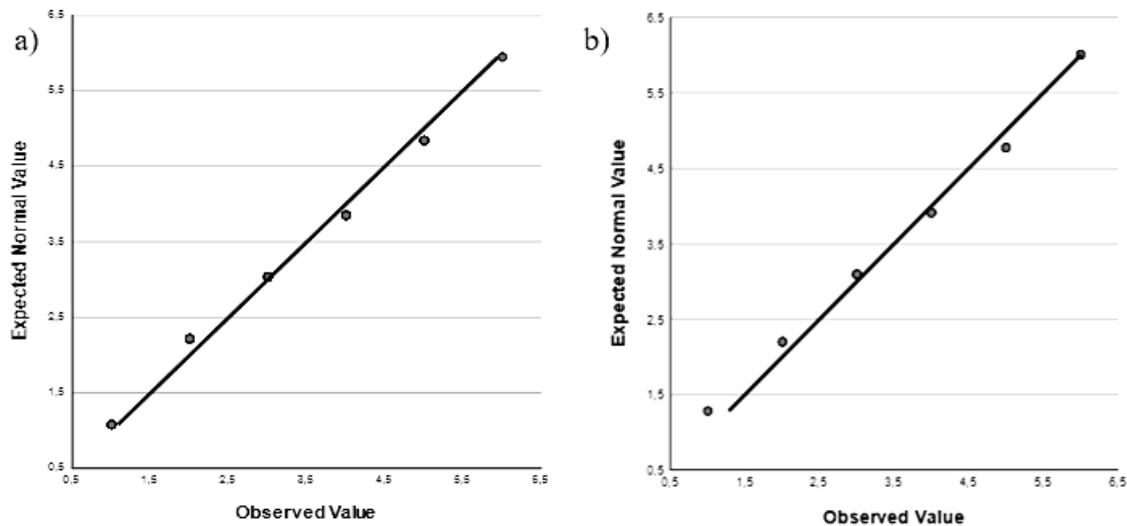


Figure 18: QQ plots for a) the affectedness of the people by Ophelia b) the concern of the people of Ireland being hit by a hurricane in the future

The QQ plots in Figure 18 show that the values of these two metric scales have a normal distribution, as the values are in one line with only slight variations and no statistical outliers can be seen. Resulting, the correlation after Pearson which requires a metric scale and a normal distribution is now proven, and the correlation can be calculated.

The correlation coefficient is $r = 0.296$, $p = 0.003$. The correlation between the variables can be described as a low positive correlation which is significant. One should also notice that the correlation coefficient lies very close to the value 0.3, from which onwards the correlation would already be a medium positive correlation.

After it is shown that there is a low positive correlation, the H_0 hypothesis can be declined. It is not the case that there is no correlation, or a negative correlation between the level of affectedness through Ophelia and the concern of Ireland being affected by hurricanes in the future. There is a positive correlation which indicates that the higher you rate one item, the higher you rate the other.

To see, if the affectedness (independent variable) influences the fear of hurricanes in the future (dependent variable), a linear regression analysis was done. The significance for the Anova lies

at 0.05 and the model r-squared value is 0.088. The regression coefficient is 0.303 with a significance of 0.05. This shows that the affectedness through Ophelia can statistically significantly display a positive correlation of the fear of hurricanes affecting Ireland in the future. However, the r-squared indicates a weak explanation of variance, as only 8.8% of the value can be predicted.

6.12 Hypothesis 10 – after Ophelia there is more fear about hurricanes in the future

Hypothesis ten is evaluated by comparison of the mode and mean values of the rating and their standard deviation.

Table 13 displays the arithmetic mean of the question “How concerned were you about hurricanes hitting Ireland before Ophelia made landfall?” and “After you experienced Ophelia, how concerned are you that hurricanes will affect Ireland more often in the future?”. The mean values are 2.21 and 3.91, respectively. The modes for the two questions are 1 and 5 and the median is 2.0 and 4.0. This shows a drastic increase in concern about hurricanes in the future. Especially the mode shows an exceptional rise. The mode shows the value that was chosen most by the participants of the survey, while the median shows the value located exactly in the middle when all answers would be listed in a row (in ascending order) and the mean shows the calculated average of all answers. However, both mean values have a relatively high standard deviation, which shows that the values vary by 1.301 and 1.451 around the mean. Having a look at Annex 2, Table 15 the answers with the most ratings for the question about the concern of hurricanes before Ophelia are one (not concerned), two and three with 39.3%, 27.0%, and 13%, respectively. For the questions on the concern of Ireland being affected more often in the future the most rated ones are five, three, and four with 25.8%, 23.6%, and 19.1%, respectively. Thus, the H_0 hypothesis of hypothesis 10 can be neglected, as the participants do feel very much more concerned about hurricanes affecting Ireland in the future than they feared hurricanes before they experienced Ophelia.

Table 13: Descriptive statistics of hurricane concern before Ophelia and in the future

	Mean	Median	Mode	Std. Deviation
Concern about hurricanes in IE before Ophelia	2.21	2.00	1	1.301
Concern about hurricanes in IE in the future	3.91	4.00	5	1.451

6.13 Overview of Hypotheses Results

All hypotheses have been assessed now and Table 14 shows a summary of all hypotheses and if their respective H_0 hypothesis was accepted (A) or declined (D).

Table 14: Overview of hypotheses assessment

No.	H ₁ -Hypotheses	Status of H ₀
1	Hurricanes are ranked higher by the people after Ophelia made landfall than they are ranked before Ophelia made landfall.	D
2	If people fear hurricanes in the future (value 5 or 6), they will assign the risk of hurricanes a value of 1 or 2 or 3 on the ranking scale.	A
3	If people were living in Cork during Ophelia happened, they will not rank the threat of hurricanes as 1 or 2 or 3 in the ranking more often than the ones that were not living in Cork during the storm.	D
4	People who have rated their affectedness by Ophelia ≥ 4 , rank the threat of hurricanes as 1 or 2 or 3 in the ranking more often than the ones that were less affected and rated < 4 .	D
5	If people assign the value 5 or 6 to the questions if they feel well informed about how to behave during Ophelia or about the threat of Ophelia, they will not add anything in the text field “what was missing”.	A
6	People who assign the value ≥ 4 to the question about how afraid they are of NHs affecting them, rank the risk of hurricanes as 1 or 2 or 3 more often than the ones that were less affected and rated < 4 .	D
7	If people rate their affectedness by Ophelia ≥ 4 , they will also state that they have been affected by a natural hazard in the past 6 years.	D
8	If people assign the value ≥ 4 to the question about how afraid they are of NHs affecting them, they will answer that they have been affected by a natural hazard in the past 6 years.	D
9	A low rating of affectedness by Ophelia correlates positively with a low rating of concern about hurricanes in Ireland in the future.	D
10	Participants feel more concerned about hurricanes in the future than they have been before Ophelia.	D

The next chapter will describe the results obtained from the expert interviews and the expert ranking. All information stated here and in the next section will be discussed in detail in chapter 8.

7. Results of Interviews

This section describes the results gained from the interviews. Each of the topics about the risk communication chain and thresholds, the content, the communication media used in different stages of the event and challenges are portrayed. In the end, the results of the expert ranking are laid out.

7.1 The Risk Communication Chain

In this chapter the initial thresholds for the start of communication will be explained, followed by a hierarchical description of the communication chain from the national to the local level and for the chains in ESB, ESBN, and HSE. Afterwards, there will be a description of changes in the chain that were made before and after Ophelia.

All risk communication for severe weather is started through one trigger. All interviewees, except for Ms Cusack, state that the warning Met Éireann issues is the start of preparation, communication, and action to manage the severe event (CD & Fire Department⁷, ESBN, Hand, Joyce, Kearney, O’Brien, p.c.⁸, 2022). Depending on the weather warning “there are different standardised advisories on how to organise the staff” (CD & Fire Department, p.c., 2022). The red weather warnings and forecasts were also the triggers to mobilise response teams for all involved emergency institutions. According to the weather predictions, regular risk assessment was undertaken to evaluate the situation of the crew members and if it is safe for them to operate in the storm conditions, which is usually not the case during a red warning (CD & Fire Department, ESBN, Joyce, p.c., 2022).

Ms Cusack as part of Met Éireann who will issue the warning had other thresholds for communication and action. The weather service provider will monitor the event several days before. This was done in cooperation between the NHC and the UK Met Office for the first time. As the storm path became clearer and the thresholds in wind were reached to issue a red warning the warning was advised by Met Éireann. Afterwards, the NDFEM published the warning officially for Cork and Kerry and others on the 14th of October 2017 and convened the NECG the same day. There, she briefed all the governmental departments, emergency services, coastguards, and representatives for energy, transport, and agriculture (Cusack, p.c., 2022).

From the NECG the information is given to the LCG and there is a steady exchange between the management levels during the event (CD & Fire Department, p.c., 2022). The LCG also receives information from Met Éireann directly. There is a 24h available weather forecaster that

⁷ All participants who do not want to be called by their name but “a representative of...” will be indicated by their institution. E.g., a representative of the Cork City Fire Department will be indicated with “Fire Department”

⁸ P.c. will be used to indicate that the source is a “personal communication”

could be called whenever needed. Further, this forecaster was giving updates every 2 hours (Joyce, p.c., 2022).

The LCC is located on the top floor of the fire station and consists of three rooms. In each of the rooms are the different agencies, the HSE, the AGS and the LA. The biggest room is the crisis management room, where the LA sits and where the communications team is included, which answers phone calls from the public, monitors SM, and manages the information exchanged between public and emergency management (Joyce, p.c., 2022). Further, the SM team will use SM as a source of information, if incidences are reported on online platforms, they will double check if these incidences were already reported via the emergency calls or through the fire brigade. If not, they will collect these incidents and report them to Mr Joyce. If the emergency team is handling them already, they get back to the people posting about the incident and let them know that the response is in progress. Further, they as well actively transfer information to the public via the SM channels about the status of the event and the work progress in the LCC (CD & Fire Department; Joyce, p.c., 2022). It was the first time that the communications team was included in the rooms of the LCC and is fixed ever since. Before they were operating from home by receiving e-mails from the people in the LCC (Joyce, p.c., 2022).

The different levels represented in the LCC are the strategic, technical, and operational levels and there is two-way communication between all parties. The information is given to Cork City Council, too, which also has a response group consisting of Cork City Council, the fire brigade, the ambulance service, the engineers, and the power generation stakeholders. The latter are involved even before the event, as there are power dams upstream of Cork City where water needs to be released in case of heavy rain events. To coordinate the release and prevent flooding in the city, communication between the agencies is key. These institutions generate information for internal staff use (CD & Fire Department, p.c., 2022). As Ophelia was a severe weather event, David Joyce, Director of Operations from Cork City Council, became a major decision maker together with the head of parks and the building managers, as Ophelia caused a great impact on buildings and trees. Additionally, there were the heads of traffic, roads, environment, water, and drainage involved. The LCG communicates with its different pillars and crews and with the CD about incidents that were reported and that the operational levels will deal with (Joyce, p.c., 2022).

Even though there were power outages during the event, the LCC was not affected by them as they have a reliable power generator that can provide Cork City Council, the city hall, and the fire station with power, ergo the communication chain internally was not affected. This generator was updated 10 years ago and is tested regularly (Joyce, p.c., 2022).

The high number of uprooted trees was not expected by the LCG and the chainsaw crews of the LCG, the fire brigade and the CD were not able to manage the clearance of roads. Ergo, the LCG was calling the local army for support as the last instance of the chain (Joyce, p.c., 2022).

The CD was part of the interagency meetings with the LCG and has been informed about the situation before landfall. The CD is not communicating officially to the public via SM during an event because they are too busy on the ground by then. The only communication with the public is in personal communication when people are out in danger, or there is communication with ships at sea. During the event, the LCG and the AGS were requesting the help of the CD in several incidents. However, the communication chain was disrupted, as the CD office in Kinsale does not have a generator and there was no mobile service out of Cork City (Kearney, p.c., 2022). Hence, Mr Kearney (p.c., 2022) and the volunteers in Kinsale created their own structures and got involved with the local farming community by personal communication. Farmers have heavy machinery and tools and the skills to help in clearing streets and fix damaged buildings, they have their local structures during an event, as they can see best what needs to be done.

As mentioned, the trigger for the ESB and HSE was the red warning that was issued by Met Éireann. However, both institutions were observing the weather forecast earlier already (Hand; O'Brien, p.c., 2022). In ESB the possibility of the red weather warning together with the observation of a second weather service triggered meetings with all network operation managers of the country. They will assemble the Networks Emergency Coordination Group, which involves different people like the call centre manager, supply chain people and area managers. Cork would have two area managers, as the county is very large. These people will be briefed about the event's characteristics and what to expect. Usually one can say:

“A yellow warning is quite routine and there the affected customer number would be around 5,000 which is relatively small compared to 2.5million customers. [...] An orange warning would be equivalent to 5,000-50,000 affected households, depending on how widespread over the country they are. But the power would be usually restored to all within 24 hours. However, a red warning is very serious, it is usually nationwide and causes severe disruption and power restoration can take several days, like in the case of Ophelia.” (Hand, p.c., 2022).

The mobilisation of staff and resources to the predicted affected areas started around Thursday 12th of October, as Ophelia would hit on Monday and preparations should be done during work-days. This is not always done that early, as wind systems can change rapidly but Ophelia was such a big system, and it was quite clear that it would hit Cork and Co. Kerry. However, during the event, the networks of ESB were severely damaged and the local crews could not handle

the repairs on their own. Ergo they requested more workforce from the UK, Northern Ireland, and France. The communication to the public about the warning about the event and its possible effects on the network started on Sunday, after the red warning. There was a huge interest in the event and the ESB press office was contacted by channels like CNN, Sky News and BBC for information. The whole time of the event (beginning, during and afterwards) ESB was publishing information to the public via their operations managers in the evening bulletins of the main public broadcasting service in Ireland, Raidió Teilifís Éireann (RTÉ), and on RTÉ and local radio through their area managers (Hand, p.c., 2022).

The local site of ESBN is not in contact with the LA or the media directly. They provide information to ESB and the control centre of ESBN in Dublin but mainly focus on internal communication. They receive information on weather warnings from their supervisors and act accordingly. They set crews on standby and dispatch them when it is safe to go outside. The information about the status of the repair sites would be communicated by the staff to the restoration supervisor who would forward the information to the control centre (ESBN, p.c., 2022).

The communication of the HSE started as well with the issued warning. When a warning is received by the emergency managers of HSE, the crisis management team, which consists of the senior managers of each region, forwards the warning to all parts of the health system, which includes the “entire spectrum of the health service, like the public health, the ambulance, the community services, and the hospitals” (O’Brien, p.c., 2022). The parts of the health service and its pillars are displayed in Figure 19. As it is not possible for the HSE emergency managers to provide the information to more than 4,000 staff members working in the health service, these services have the responsibility to provide the information to their staff and follow the top-down communication chain. Each institution of the health service should then follow its own EMPs for severe weather that should be developed before the event together with Mr O’Brien. This also includes the information to staff and patients and the cooperation with other parts of the health service, e.g., the communication between hospitals to make sure all patients can have their appointments rescheduled as soon as possible. This is especially important for critical patients (i.e., dialysis, chemotherapy). The communication with other agencies is mainly between the HSE and the LA. The HSE informs them about blocked roads in case the ambulance service reports some and to get advice about the situation during the storm so he can assess how to prepare the health service for this event. Further, they provide the LA with information from the health service, which is relevant to people, as the HSE does not communicate directly to the public (O’Brien, p.c., 2022).

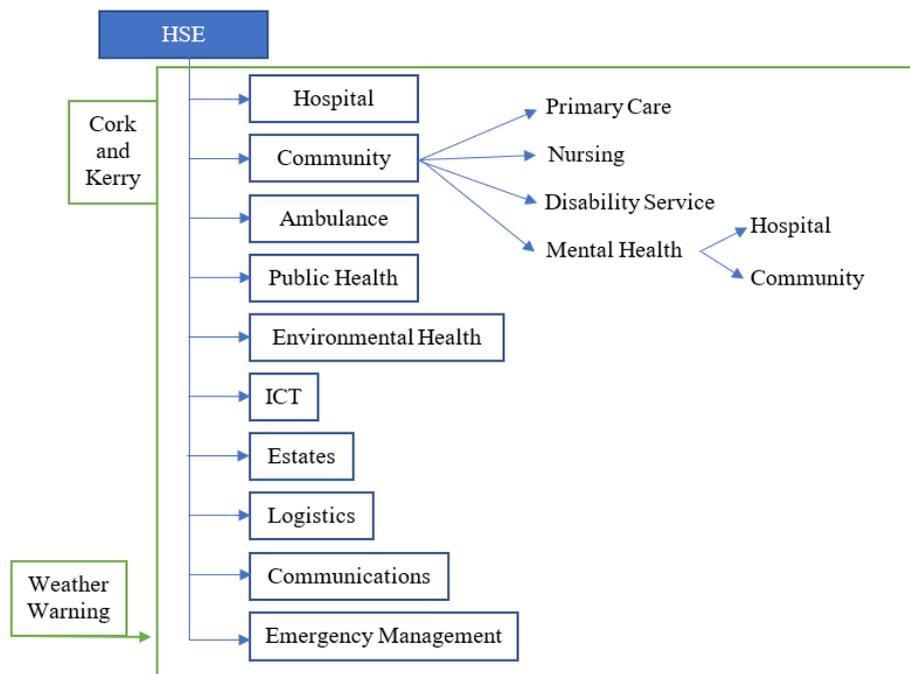


Figure 19: Pillars of the health service
 Graphic created by author from interview content with O'Brien (p.c., 2022)

After Ophelia changes happened in the communication chains. For example, the LCG would rely more on local communities. Through the pandemic, the local networks became very strong, and it is easier now to reach several people at once. Thus, the LCG would first rely on social community networks and afterwards would call in for the CD. This is, however, not yet tested as there was no major severe weather event since the pandemic started (Joyce, p.c., 2022). Additionally, there was the change, that not all county red alerts portray the true situation locally, hence, an assessment for the local level is done and included before the national message is forwarded to the public (CD & Fire Department, p.c., 2022).

After Ophelia, Met Éireann mainstreamed the cooperation between the NHC and the UK Met Office in the case of PTCs. Every time a hurricane is approaching, there are regular briefings between the three agencies (Cusack, p.c., 2022).

In ESB and ESNB there was a big restructuring in the emergency management task of each employee after Ophelia. There were adjustments in roles together with training courses, so every person knows their role (ESBN, p.c., 2022). Further, there is more staff only assigned for communication during the event, despite the ESB press office. This is not done anymore by the supervisors who do not have training in communications but by professionals (Hand, p.c., 2022).

The HSE did not change its structure after Ophelia, but they still use the same structures as back then (O'Brien, p.c., 2022). However, Mr O'Brien (p.c., 2022) stated that "severe weather planning was relatively new in the HSE there was no specific severe weather guidance in the HSE

at the time.”. The inter-agency chain changed a bit though. The warnings of Met Éireann were only received sporadically and only came regularly in the past three years. Before “it was a roulette if they would receive the information and warnings from Met Éireann or not.” (O’Brien, p.c., 2022). Still, through Ophelia, the pillars of the HSE changed their attitudes to severe weather management and planning. It is taken more seriously. And after snowstorm Emma in 2018, which lasted three days, the procedure for the staff changed as well. In case of a red weather warning, the staff that comes in early or uses a hotel to be close to their workplace is paid to do so. Also, patients with critical treatment are now better dealt with. There are lists for prioritisation which include, name, address, mobility status, schedule for treatment and distance to the hospital. Moreover, a pre-check of the treatment facility is done now before the facility opens again, to make sure that no damage occurred to the building, and everything works properly. This was not done back in 2017 (O’Brien, p.c., 2022).

7.2 The Risk Communication Content

This part summarises the statements about the risk communication content that was given out to the public, between the agencies and within an agency. The content changed only slightly during the event.

In general, all institutions that have been interviewed here (and are not the weather warning producer) agreed on the fact that they only disseminate orange and red weather warnings to their management crews and pillars, as these are the critical warnings, while a yellow warning can be interpreted as typical Irish weather. They further all indicated that the phase before Ophelia hit was the most communicative one. Here all information regarding the storm, its preparations and precautions were communicated (CD & Fire Department, ESBN, Hand, Joyce, Kearney, O’Brien, p.c., 2022).

In preparation for the event, the communication content of the LCG to its response crews was simple. The preparation was done by securing tiles and cranes and by cutting down old or damaged trees. Before the red warning came into place the crews were called back to their depots to shelter during the red warning and only the emergency response, like fire brigade, ambulance and AGS were allowed on the streets, however, only for life-threatening situations. After Ophelia did cause damage the chainsaw crews were sent out again and were told to first remove the trees from the prioritised roads in Cork and Cork City (Joyce, p.c., 2022). The fire brigade would be a source of verification for reported incidents and would communicate the severity and the status of their proceeding with the incident to the LCG. These reported incidents came through SM or the emergency number of the LCC. After the fire brigade assessed the case, the communications team would include the information in their next communication with the public (CD & Fire Department, p.c., 2022). Further, there was steady communication of the status

of the tidal gauges internally and with the Office of Public Works, to observe if flooding is expected. Moreover, there was steady contact with ESB about the progress in restoring power to the customers in Cork (Joyce, p.c., 2022).

When it comes to communication with the public, Cork City Council with the LCG is the main disseminating agency for public communication locally. They coordinate the messaging via various channels. Communication included the information the LCG gains from national groups like the warning and its colour code, advisable actions and how to behave during the event together with information and advice provided by the fire brigade, like “stay inside and shelter” as typical storm warning and how to assess fallen wires. Here the warnings are standardised (CD & Fire Department, p.c., 2022). The concrete message would be like what Mr Joyce stated in the interview:

“They [the public] were probably not able to go to work, open their businesses, bring their children to school and plan accordingly. [...] Additionally, to this message, there was information given, e.g., if you have a backyard secure your furniture there, and secure trampolines. The messages for businesses were similar: secure the furniture, get hanging flowerpots inside, and for construction sites, messages were: secure work material, secure poles and loose elements not yet fixed in construction, like tiles and poles etc. secure your scaffolding and cranes even better than under usual events because the wind was expected to be worse than the one that they had in man many years” (Joyce, p.c., 2022).

They also advised the people to have their phones charged before the event starts, have a battery radio at home, in case of power loss (Joyce, p.c., 2022) and forward the warning messages to their neighbours and elderlies in the area (Joyce, Kearney, p.c., 2022). Moreover, Ophelia was the first red alert with a stay-home implication from the national level (CD & Fire Department, Joyce, p.c., 2022). Ergo the government closed schools, workplaces, and public buildings (Kearney, p.c., 2022). This was a benefit as this message was issued nationwide and according to Mr Joyce’s (p.c., 2022) expertise people take warnings more seriously if they are issued nationwide, constantly and uniformly from several different institutions and even from the Taoiseach (Prime Minister of Ireland). The messaging would develop constantly throughout the event and include information about blocked and reopened roads, power outages and when to expect power back. It would always include advice on how to behave, the newest updates from the Met Éireann forecast and all other agencies and the LCC emergency number that provides a link between the LCC call centre and the public. This number is a contact to report non-live-threatening urgent situations to the LCG and is published in every press conference and media statement (Joyce, p.c., 2022).

Even though most of the interviewees state that there has been information on how to behave, this was not sufficient in the eyes of Mr Kearney. He believes that there was no information on how to behave, no information on how to prepare for the emergency, like having a first aid kit and having bottled water and cooked canned food at home. Further, there was only the implication of not going out, without giving reason why this should not be done. He thinks that people obey better to information where a cause for a special desired behaviour is given (Kearney, p.c., 2022).

In the CD, the ESBN, the fire departments and the HSE, staff would be informed to come together early in the areas that are predicted to be affected by Ophelia before the red weather warning came into place. They all were preparing for the event by getting crews and staff ready (CD& Fire Department, ESBN, Hand, Kearney, O'Brien, p.c., 2022), preparing machinery, depots, and tools (ESBN, Kearney, p.c., 2022), or activated their severe weather management plans (O'Brien, p.c., 2022).

The ESBN restoration supervisor would inform the restoration crews about the preparatory tasks and what to expect from the event, like severeness and time of landfall. After damage occurred and the risk assessment showed that it was safe for the crews to go out the supervisor would dispatch them to the damaged sites according to their priority (ESBN, p.c., 2022). There is a database of vulnerable customers, like elderly, or people who need medical equipment to survive. Thus, according to this database restoration was prioritised additionally to power masts for phone services, and facilities of Irish water, like pumps, wastewater treatment plants, and hospitals (despite them having generators) (ESBN, Hand, p.c., 2022). Telephone masts are of importance for ESBN itself as they rely on the mobile connection between the management room and their response crews. The crews on the field would then get information back about the status of the fault they are working on. In the evening, the restoration supervisor, and the storm supervisor of ESBN would have a phone call and exchange about the progress of the day and what still needs to be done, together with the estimated restoration time needed. This information would then be forwarded to the restoration crews in a briefing the next morning, together with risks they might face on specific sites. The only information the restoration manager would prepare for the public is the approximate time of restoration. The ESB would do most of the communication for ESBN via their press office (ESBN, p.c., 2022). The press office provides nationwide messaging on Sunday afternoon, prior to the event, about what to expect:

“expect outages and give the advice to charge phones, have torches and candles ready, turn out all appliances, leave one light switched on to see when power is restored, use the power checker app or website, report any damages through our emergency number, stay away from ESB infrastructure when it came down, like fallen lines, damaged poles” (Hand, p.c., 2022).

The online application “ESB power check” shows the areas without power and the expected time of restoration. This information was also implicated in every press release during the event. The ESB press team even took RTÉ camera crews with them on a helicopter to provide the people with pictures of the damage to support their message that people might be without power for 10 days with pictures of the reason for the restoration time. And after political pressure rose, they offered free warm meals for people still without power via local radio. However, this offer was not used and Mr Hand thinks that could be because people without power could not get this message. Additionally, there is no specific warning on how to prepare for being out of power for several days. Here ESB is relying on other channels, like the CD, to provide the people with this information (Hand, p.c., 2022).

In the HSE the preparatory phase is the most communicative one. In advance, they advise each of their pillars in the creation of a severe weather management plan and support them in the things that should be included in the plans, like letting staff come in early and rescheduling appointments during weather warnings. When a severe weather event is approaching, the emergency management team of the HSE double-checks the management plans in place with the pillars and assesses how they are fixed, even though they know that they cannot improve the plan anymore by then but can only raise awareness in the health institute. On the day of the event, the services are shut down and they only deal with life-critical incidents during the phase of the warning. The HSE will communicate the following information to the LCG: Information about the number to call in case of emergencies, the shutdown, the rescheduling of appointments afterwards, and the possible delay of health services due to blocked roads. The LA will then forward this message to the public as the lead agency of severe weather. Communication with the patients is done by the health institute itself. In case of a weather warning, the HSE would disseminate the warning to all its pillars. The hospitals, for example, would provide this information to its clinical staff and this staff would then inform the affected patients, who have an appointment that day or in the days after the event -if the hospital has such a plan in place- and make them aware of coming in early, rescheduling of appointments and possible difficulties the next day in coming to the hospital (O’Brien, p.c., 2022).

In the years after Ophelia, there have been some changes in the communication content. Beginning with Met Éireann they started forecasting medium-range predictions six to ten days in advance to prevent that rumours in SM cause panic about an event. This forecast comes together with a meteorologist’s commentary and with some audio and video commentary. Additionally, there are ensemble predictions and three-day warnings available, hence the onset, duration and end of a warning can be better understood nowadays (Cusack, p.c., 2022).

After snowstorm Emma in 2018, actual local situations were included next to the nationwide red alerts in the communication with the public. As with Emma, the red alert was lifted, but Cork was still badly affected by snow. Since then, Cork lifts the red weather warning quite late as Cork is the largest county and there can be several different situations across. Especially for flood forecasting, the fire brigade became experts over the years. Further, warnings about fallen trees were much more included after Ophelia and over the years the advice for the public became simpler. Instead of the message “tie down all loose objects, take down your trampolines” the message has developed and simplified to “put away your garden furniture because it will fly around” (CD & Fire Department, p.c., 2022). However, Mr Joyce (p.c., 2022) stated that “in terms of message content, there was not much change”. Also, in internal communication improvements were made in terms of risk assessment for the staff (CD & Fire Department, p.c., 2022) and crews learned to report back to the LCC when they have cleared an incident to make communication to the public as quickly as possible (Joyce, p.c., 2022). The mindset of the risk managers changed according to the wish of the public of knowing everything as soon as possible. Thus, the communication changed from reactive to proactive communication (CD & Fire Department, p.c., 2022).

Nowadays ESB actively monitors the restoration efforts with photographers and cameras to provide their customers with pictures of the damage and the progress (Hand, p.c., 2022). In ESBN they improved internal structures. Now they could reduce the number of doubled incoming emergency calls. The outage management screen was reframed, and the training helped to have the best scenario of how to run a storm-impacted network restoration (ESBN, p.c., 2022). The internal communication in ESBN and the content of advice to the public from ESB did not change over the years (ESBN, Hand, p.c., 2022).

The preparatory planning the HSE does with its pillars was more successful after Ophelia because there was awareness of shortages in existing and non-existing plans. After Ophelia, it became a culture to bring staff in early or close by in a hotel and see the benefits of this, especially if the staff is living in rural Cork. The content of the messages during the event internally and to the public is unchanged, though (O’Brien, p.c., 2022).

7.3 Communication Media

This chapter describes the media used to disseminate the communication described above during the different stages of the event.

According to Mr Joyce (p.c., 2022), there was no change in the used media to communicate with the public. The LCG was continuously providing information via all available channels equally. Especially local radio is a very important medium for communication in Cork as the radio runs in a lot of households and work sheds the whole day, and particularly the elderly rely

on the local radio as their number one source of information. Here it is important to have the information that is disseminated as timely as possible, specifically the information about blocked roads and their clearance. The LCG would also rely on informal networks, like friends informing each other about the advice given by the LA (Joyce, p.c., 2022).

After Ophelia did strike and the red warning was lifted a lot of people went out on the streets again and the number of calls via the emergency hotline rose as people were reporting many incidents, especially about fallen trees. However, the eight staff people could manage the calls and there was no more than 10 min waiting in line (Joyce, p.c., 2022).

For ESB, the national TV and radio service “RTÉ” is the most important media, together with their website and SM as they mainly get out information on the national level. Also, the call centre, where people could call to get information was used nationally. In Ophelia, they also broadcasted via local radio (Hand, p.c., 2022).

The HSE communication team would use SM like, Twitter and Facebook to disseminate messages to the public but solely to provide information and not to engage with the users (O’Brien, p.c., 2022). Figure 20 shows the continuously used media, the one used during the event (after Ophelia made landfall and before the power restoration was completed) and that was introduced or mainstreamed afterwards (in the years after Ophelia after the power restoration was completed) to communicate with the public.

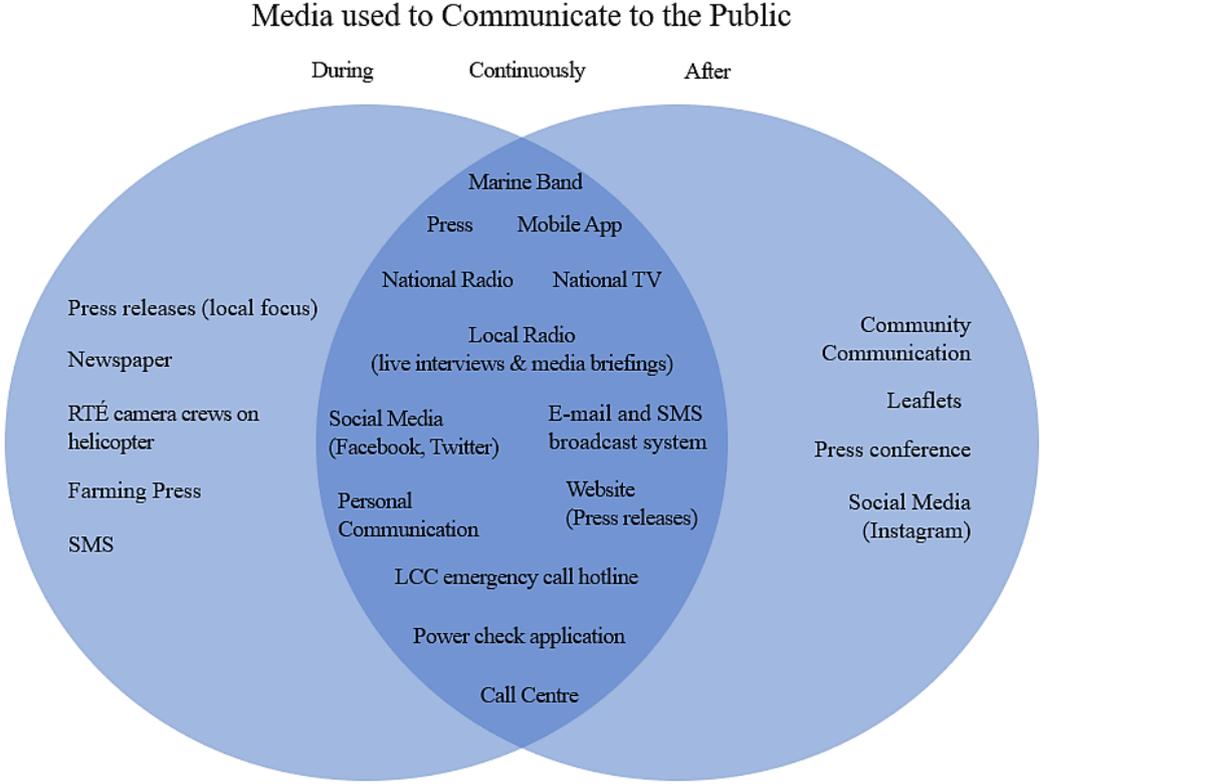


Figure 20: Media used to communicate to the public
 Source: Created by author, based on information of interviewees. See Annex 4 for the list of codings.

When it comes to internal communication the HSE would rely on phone calls via mobile phone and in case of power loss, the HSE emergency management team would have Terrestrial Trunked Radio (TETRA) radios⁹ available (O'Brien, p.c., 2022).

Nevertheless, there have been some major communication challenges due to the impacts of Ophelia on the power network and the fact that ESB could not restore the mobile masts fast enough before the connected emergency generators were empty. Especially Mr Kearney, who is located in Kinsale as a CD officer, suffered loss of mobile connection in proceeding of the event and could only reach the on-site coordination centres via TETRA but was not able to communicate with the LCC anymore because the LCC did not use TETRA radios at that time (Joyce, Kearney, p.c., 2022). Hence, Kearney (p.c., 2022) relied on the resources on the ground, like its volunteers and social networks.

Also, the representatives of the CD and the Fire Department (p.c., 2022) were stating issues about power outages and that the local radio became the most important information media to the public. The radio stations could still be reached via landlines, press releases and e-mails as the LCC has a power generator, and in Cork City itself, people mainly had power. However, mobile service was not available and staff on duty needed to come into the LCC and get their tasks by personal face-to-face communication, if they did not have a landline available at home “it was complete chaos”. Also, the LCG reacted to the power failure in the County and one person from the LCG was assigned to either do live updates on local radio or disseminate written statements to them hourly (Joyce, p.c., 2022). Mr Joyce and ESB, as well relied on the mobile network to stay up to communicate with their crews on the ground, which was the case in the city and some areas in the County. Ergo, both parties were not concerned with communication difficulties via mobile (Joyce, Hand, p.c., 2022).

Nevertheless, HSE and ESBN both had problems communicating with their staff. Mr O'Brien (p.c., 2022) stated that “there were huge telecommunication issues after Ophelia, and these could only be overcome by driving around till the phone was charged [by the car battery] or one got service”. The representative of ESBN stated similar issues. There were severe telecommunication issues between the restoration manager and the crews, as they shifted to TETRA instead of mobiles. However, there was only one TETRA per crew and not every crew would have one. The crews without TETRA needed to proceed the same way as Mr O'Brien. After a few days of difficult communication, more TETRAs were brought in. The communication with the control team in Dublin and the storm manager was not disrupted as they were communicating via landline and e-mail as the offices all have generators (ESBN, p.c., 2022).

⁹ TETRA radios are a kind of two-way radio or walkie-talkie.

An overview of the used media for intra- and inter-agency communication is shown in Figure 21.

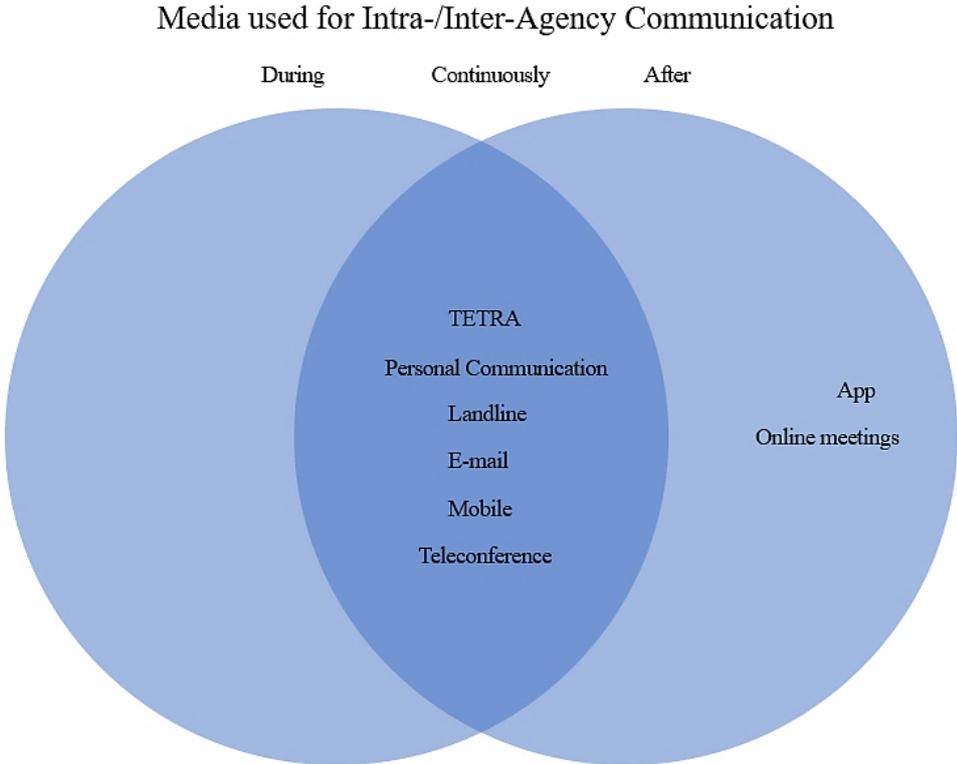


Figure 21: Media used for intra-/inter-agency communication
 Source: Created by author. Based on information of interviewees. See Annex 4 for the list of codings.

During the years after Ophelia, there have been some changes in the media. Through the development of new SM platforms nowadays Instagram was included as a SM platform for communication with the public (Joyce, p.c., 2022). Further, the e-mail and SMS broadcast system¹⁰, which people can sign up for and has been in its infancies during Ophelia, became more popular as a source of information (CD & Fire Department, Joyce, p.c., 2022). Additionally, new communication strategies are tried out in Cork City for events that appear relatively often. Hence, there were leaflets given out before a predicted flood event, where unusual areas were supposed to be affected. Leaflets were handed out to store and property owners typically not affected, to make them aware of the special situation of the flood and to prevent, that they ignore the warning due to warning fatigue (CD & Fire Department, p.c., 2022). Different strategies were as well used in the ESB. Directly after Ophelia, storm Brian was approaching and ESB changed their method of warning from press releases to press conferences to make people aware that a new storm cell was approaching and that these messages were new and not related to Ophelia (Hand, p.c., 2022).

¹⁰ The e-mail and SMS broadcast system is called “Cork City Now” and people can sign up to it via the webpage of Cork City Council (<https://www.corkcity.ie/en/council-services/news-room/cork-city-now/>).

Particularly after two years of COVID-19, there have been some advantages in communication. The community solidarity increased during this time and Mr Joyce thinks, that there could be communication chains between the LCG and communities as a step before calling in the CD. The communities usually have more than 100 people in them and look after each other, thus they would know who is out of power or who needs special care (Joyce, p.c., 2022). Inter-agency communication did advance as well. Single briefings can now be done via online video meetings (CD & Fire Department, Cusack, Joyce, p.c., 2022) and the HSE emergency management team of Cork and Kerry is equipped with a management room, that has several TVs, a whiteboard, projector, and a telephone where conferences are possible. This was all not in place during Ophelia. However, there is still no generator in the building (O'Brien, p.c., 2022). In ESBN they introduced a mobile app for the repair crews, where the teams can upload the status of the site, what tools are needed for the repair, what is still missing and can tell if a site is completely fixed and reconnected. This can then be seen by the restoration manager in his office, and he can send tools there, if needed, and is always updated directly about the status of the site.

7.4 Challenges

During Ophelia, a lot of challenges were faced in terms of communication, notably due to the widespread power outages and due to blocked roads. As mentioned, the understanding of the benefits of rota staff coming in early to work, or at least close by was only realised after Ophelia (O'Brien, p.c., 2022). During Ophelia, there have been issues of health service staff that could not be reached by phone or could not reach their workplace due to blocked roads, own issues, or high risk. Thus, it was difficult to hold up treatment in hospitals because of missing staff. Moreover, ambulances could not pass, and the CD needed to transport people with their 4x4 vehicles to hospitals (Kearney, p.c., 2022). Also, Mr O'Brien (p.c., 2022) needed to coordinate an ambulance service, as there have been 3 emergency calls (112/999) from Cobh, but the only road leading there was blocked by a tree, so one ambulance came from Cobh to one side of the tree, and another came to the other side. Patients were lifted above the tree blocking the road and could afterwards be transported to treatment by the second ambulance.

The storm was challenging for the LCG staff as well, as they needed to rest at home at one point. Hence, the staff then moved from a power-equipped workspace to their homes just outside the city and mobile service and power were not available anymore. Thus, they could not receive any updates between their rest and the next shift (CD & Fire Department, p.c., 2022). If there would have been a failure of mobile and landline communication in Cork City the LCG would have probably sent drivers out to the depots to inform the response crews about the most recent information (Joyce, p.c., 2022). Further, there is little knowledge of whether people

without power and mobile service could still call the emergency number. Though it is possible, that they could not reach this number in case they do not have a working landline (CD & Fire Department, p.c., 2022).

In general, local messaging is important as “national red alerts are beneficial and difficult at the same time especially in the management zone of Cork and Kerry, with a long coastline” because the warning might apply to the coast but not to the inland, which was not the case during Ophelia but is the case in several other incidents (CD & Fire Department, p.c., 2022). Additionally, pre-planning in terms of the creation of emergency plans is always difficult because institutions have a lot of other challenges that need to be dealt with right now. So, often there is a lack of time to focus on events that might happen in the future. Especially with COVID-19, the focus on severe weather preplanning declined in the pillars of the HSE and in general (O’Brien, p.c., 2022).

7.5 Improvement Suggestions

This section will focus on the improvement suggestions that were proposed by the experts and that were found in the survey as well as some statements that were given at the end of the survey of participants voluntarily. The results of the expert ranking will be shown in subchapter 7.5.1.

From the survey, some improvement suggestions could be gained for risk communication. People wished for more information on preparatory measures they can undertake in case they are adversely affected. All the following statements can be found in Annex 2, Table 23. People asked: “What to do if house destroyed and have nowhere else to go etc.”, “What is the safe and correct thing to do if a certain situation occurred e.g., water supply lost”, “List of things to do to protect yourself during a hurricane”, and “Safety instructions, how to prepare etc.”. Also, some information about the storm itself was wished for, like information about the mild temperatures and “What separates this event from a normal ‘bad’ winter storm”. Moreover, one person wished for a “more accurate damage expectation per area”. Interestingly, one participant wished for information on the reconnection of power which, according to all experts was disseminated via all channels after there have been power outages.

At the end of the survey, people had the possibility to state thoughts they had about the risk communication of NHs that were not assessed in the survey. Here some improvement suggestions were given as well or could be read between the lines (a full list of statements can be found in Annex 2, Table 24).

1. Leaflet drop-ins for elderly people by the post about how to keep oneself and property safe, which services will be open, and which will be closed, where one can call for support

2. Information about the expected impacts of the event and their spatial extent
3. More communication about the greater costs of inaction or inadequate inaction in terms of slow adaptation due to slow policy evaluation
4. Uncertainties of predictions should be communicated to the public
5. Fewer alarmist media broadcasting for normal storms as this behaviour can result in warning fatigue
6. The colour scheme warning system of Met Éireann should be applied for all hazards mentioned in the survey¹¹
7. Have politicians communicate for very serious events
8. Better power backups at relay stations for phone service
9. More transparent and effective infrastructure for extreme events, like in Texas
10. Have numerous alarm systems in place that warn people in case of NHs, like the tsunami warnings in Japan
11. Each type of natural hazard should have its own early warning system.

From the interviews with the experts, several improvement suggestions could be gained. Experts were as well proposing some of the ideas the survey participants were already stating. The following list shows the improvements that could be collected from the suggestions the experts made (a list of suggestions of each interviewee can be found in the codings in Annex 4). The first 14 suggestions were the ones that were used in the expert ranking. The other suggestions had less to do with communications or were not relevant for all risk communication institutions equally. The order here is not indicating higher importance.

1. Have education and regular training for citizens for emergencies which starts in school education.
2. Include behavioural advice in case of emergencies into risk communication before the NH hits, as well as the reason why orders and advice are given.
3. Have impact forecasting instead of weather forecasting.
4. Have a central building in each city/town that functions as a supply centre and shelter with a generator, where people can get hot drinks and food or where necessary goods can be delivered to.
5. Have regular training for emergency managers and response teams on how to use TETRA radios.
6. Have regular training for emergency managers and response teams on how to interpret weather maps.

¹¹ This would be necessary for floods, storm surges, wildfires, and landslides. To the other NHs in the survey it is applied already (Met Éireann, 2022).

7. Have a user-friendly GIS map where people can see which incidents are reported, which are cleared, where teams are currently working on, and where people can report incidents in a standardised structured manner.
8. Have clarity if each red warning equals school and business closure and be concrete about which educational services are included in “school closure”.
9. Have specific communication for people with disability, mental health issues, blind people, etc.
10. Have special security plans for livestock.
11. Have childcare available for people in system-relevant employment who also work during red warnings.
12. Have more trained staff working on a 24/7 rota in emergency management, especially if warnings are coming in on weekends.
13. Have larger backup generators at masts that provide mobile service.,
14. Have a sufficient amount of TETRA radios available to provide every crew with at least one TETRA.
15. Have earlier warnings, especially if a warning is issued on weekends
16. Communities (especially farming communities) should be seen as part of emergency management, as they have connections, vehicles, tools, and machinery at hand. However, they need to be supported with proper insurance if their belongings are damaged during the emergency works
17. Have something like Federal Emergency Management Agency (FEMA) in the USA to have an organisation that brings together emergency management and NH knowledge and coordinates the actions and improvements in an integrated and proactive manner
18. Have proactive and integrated improvement in emergency management and not reactive
19. Always do a debrief after each event with the help of frameworks on how to assess, performance, preparedness, and new improvements
20. Have information for health staff and patients that road blockings could be an issue, even after the red warning is lifted and that they need to plan accordingly

7.5.1 Results of Expert Ranking

The ranking of the improvement suggestions shows that the inclusion of behavioural advice before the hazard hits and after the hazard did strike is most important for the experts followed by education and training for the population and a wish for change from weather forecasting to impact forecasting. The three least important improvements for the experts were larger backup generators at mobile masts on rank 12 followed by having a central building with a generator and the security plan for livestock on rank 13 and 14 respectively. Below there is the list of the

improvement suggestions in their ranked order from one (most important) to 14 (least important), a full list of the ranking by each expert can be found in Annex 5, Table 32.

1. Include behavioural advice into risk communication before the NH hits and advice on how to organise for impacts afterwards, as well as reasons why orders and advice are given.
2. Have education and regular training for citizens for emergencies which starts in school education.
3. Have impact forecasting instead of weather forecasting.
4. Have a user-friendly GIS map where people can see which incidents are reported, which are cleared, where teams are currently working on, and where people can report incidents in a standardised structured manner.
5. Have specific communication for people with disability, mental health issues, blind people, etc.
6. Have more staff working on a 24/7 rota in emergency management, especially if warnings are coming in on weekends.
7. Have a sufficient amount of TETRA radios available to provide every crew with at least one TETRA.
8. Have clarity if each red warning equals school and business closure and be concrete about which educational services are included in “school closure”.
9. Have regular training for emergency managers and response teams on how to interpret weather maps.
10. Have regular training for emergency managers and response teams on how to use TETRA radios.
11. Have childcare available for people in system-relevant employment who also work during red warnings.
12. Have larger backup generators at masts that provide mobile service.
13. Have a central building in each city/town as a supply centre and shelter with a generator, where people can get hot drinks and food or where necessary goods can be delivered to.
14. Have special security plans for livestock.

8. Discussion

This chapter will discuss the results gained during this research and will focus on the limitations of the methods, the change in risk perception and the change in risk communication over the years. Further, it will connect the findings of the research to the theory.

8.1. Limitations of Methods

One must notice that even though the random sample of this survey is statistically relevant as it is exceeding the value of 30 participants, the results could have been more accurate if more people would have participated in the survey, particularly the standard deviation could have been reduced this way. Especially if one is considering that 89 valid responses show the opinion of 542,868 inhabitants of Cork. Moreover, the age distribution of the participants misses a proper base of people over the age of 75. This might be due to the fact that the survey was published online and in Facebook. Elderly might not have access to this SM network and might have been excluded thereby. It should be considered to have an online and paper survey when doing the next evaluation to avoid this influence on the distribution of age groups.

Further, some passages of the survey could have been improved in wording to reduce unwanted interpretations. The question “Which natural hazard, that occurred to you, was the most devastating one in your opinion?” was formulated too drastically as some people were saying that they do not consider the hazard “devastating”. Further, there might have been confusion about the wording “I was not affected” in the question “How were you affected [by Ophelia]?”. It seems like people were interpreting this option as “I was not harmed or injured personally”. More about this matter can be found in chapter 8.2. Additionally, it is always a risk to ask people to consider something in their past. The question “Do you think you would have ranked the natural hazards mentioned before differently prior to Hurricane Ophelia?” can only be answered subjectively and can be influenced by memory bias. However, the question was included into the survey, as there is no risk perception data available on NHs for the people in Cork till now.

For the interviews, it was a shortcoming that not all the desired interview partners were able to participate in the research and contribute with their knowledge. Further, it was difficult to create contact, as people were quite suspicious about being contacted by a German student or being called by a German phone number. After the interviews were conducted and during the summary process, it might have happened that specific wording, chosen by the interviewee was changed and only the sense of the content was summarised. Thus, it might have happened that information was described as more drastic or less important by the interviewees than it appears in the summary. Hence the analysis is completely based on summarized interview content that might be slightly influenced by the author. Still, as the content is more important in this work

than the wording used by the interviews this has only a minor effect on the results presented here.

Also in the expert ranking, only six of the seven experts that were contacted participated. Even though they are all from different institutions the ranking results could have been different if more experts from all these institutions would have contributed. There it could have been interesting if there is a trend in which institution votes for which improvement more often for a higher or lower rank. Further, the ranking is only based on the importance of the suggestions to the institutions. In this work, there is no focus on trade-offs, financing, or realisation of the suggestions. Another research which assesses the improvements with more experts in another ranking and considers the costs and possible implementation strategies could show the most efficient and/or cost-effective option.

8.2 Change of Risk Perception

In general, one can say that people in Cork are not overly concerned about being affected by NHs. Most of the people rated their concern about being affected by NHs with a value of one or two. As there are usually no or only very few fatalities caused by the NHs affecting Ireland this can be understood as lay people associate high risk with events causing many fatalities, even though the probability is low (Fischhoff et al., 1993). Further, there is possibly a low feeling of dread, which as well influences the perception of risk (Slovic, 1987; Slovic et al., 2004) as there are only a few events which disrupt services in the county.

However, one is surprised that 2/3 state that they have not been affected by natural hazards because Cork is affected regularly by NHs, especially storms (Met Éireann, 2018a) and floods (CD & Fire Department, Joyce, p.c., 2022). Only 1/3 state they have been affected. Of these people most were affected by storms, hurricanes, flooding, or snow and ice. All the mentioned hazards are known in Ireland and were as well mentioned in the interviews and the literature as stated above. Also, the mentioning of snow and ice is not unexpected. There was the long lasting snowstorm Emma which covered Cork in snow for 4-5 days in 2018 (NDFEM, 2019).

Interestingly, even though people stated here that they have not been affected by NHs, most of the people still stated that they were affected by Ophelia. There are high discrepancies between these questions. People were asked in question two if they have been affected by NHs in the past six years. Following they have been asked to rate their affectedness by Ophelia (not affected vs. very much affected) and they were asked how they have been affected. At first, 2/3 stated that they have not been affected by NHs in the past six years, then only 14 people rated that they have not been affected by Ophelia and in the last question 26 people stated that they have not been affected. Of the 26 people who stated: "I was not affected", only 11 also rated "not affected". It can be assumed that the people did understand the sentence "I was not

affected” like “I was not personally harmed or injured”. This would explain the discrepancy here. It could also be the case that people had a different understanding of what a NH is. In future research, a more unequivocal formulation should be used. Nevertheless, during the start of the survey and before the topic of Ophelia was introduced people of Cork still did not feel affected by NHs, even though they have been affected by Ophelia. This could be due to the time that has passed since Ophelia. It could be that people were not sure that Ophelia happened in the last six years or that they forgot about Ophelia before they were reminded by this survey. Two participants were stating that Ophelia is far too long ago to remember.

Still, the perception of the risk of hurricanes is high among the people from Cork. Even though the NHs most perceived as risky are storms and floodings with rank one and two. Respectively, hurricanes were ranked in 3rd place as the hazard they feel threatened by most after Ophelia happened and hurricanes ranked in 8th place when the citizens were asked how they would have ranked before they experienced Ophelia. Even though only 27 people stated they would have ranked differently prior to Ophelia, this is a big difference in rank. After analysis of the answers, it can be assumed that people might not have ranked differently due to the following reasons. Many people ranked storms and river and coastal floodings as more frightening than the specific hazard of hurricanes in general. Thus, hurricanes generally were ranked somewhere in the middle, and this would not change before Ophelia made landfall. Additionally, some people in this survey experienced other hurricanes before (mainly in the USA). It could also be that this specific hurricane made them rank high and Ophelia is not the first association here. Moreover, a heat wave is ranked in third place after people were asked if they would have ranked differently prior to Ophelia which makes storm surges fourth place, same as in the first ranking. This is a bit surprising, if one considers the length of the coastline and how many people live in direct vicinity to it. Still, it can be connected to an awareness-raising campaign that was promoted this summer by the Department of Defence named “Be summer ready” which focuses on possible threats of warm weather and how to prepare for them (Department of Defence, 2022a). The fact that heat waves are ranked as 3rd show that this campaign was effective among the participants.

Another interesting aspect of the ranking is that people were naming storms, hurricanes and snow and ice as the hazards they have experienced as the most devastating ones in the open question. However, snow and ice were not mentioned once as a hazard in the ranking under “other”. Here most people stated tsunamis (four out of 17). Further, there were mentions of other not very likely hazards, such as “earthquakes”, and “house being struck by lightning”. This is not unusual, as people fear NHs that they do not know much about or they cannot understand (Slovic, 1987). Further, they do not consider the probability of an event as long as it can cause dread or many fatalities it will be perceived as risky (Fischhoff et al., 1993). Here one person even stated that he is afraid of “the unknown ones”, which supports this statement.

To try to explain some of the reasons for the ranking, the information in chapter 4.1 was used. The literature state that people who understand a hazard very well (as can be assumed with wind events in Ireland) have a lower risk perception of the hazard (Slovic, 1987). This can be confirmed if we say that people living in Cork are very familiar with wind-related hazards due to their frequent occurrence. Connected to this statement it makes sense that the hypothesis that people of Cork will rate hurricanes under their top three NHs they feel threatened by most more often than people not from Cork is not true. Here, the people from Cork did rank it less often than the ones that have been outside of Cork during Ophelia. This could be due to a better understanding of the event and its effects nowadays by the people living in Cork. Still, it could also be because of fewer power outages or outages that were restored faster in the area outside of Cork, which enables the people there to follow the news more easily and be supported with pictures of destruction compared to the information the people of Cork got. The pictures of destruction and fallen trees could have caused a higher threat to Ophelia than the people who could only observe the damage around their neighbourhood. Moreover, it could be that the warnings were very intense for Cork and that, in the end, people were not affected as badly as they were assuming or associating due to pictures, they have seen of hurricanes affecting the east coast of the USA, for example. However, there have been only 10 people outside of Cork during Ophelia who answered the survey question, thus, this statement is not very representative, and it would be interesting to do further research on how far the location of participants affects their risk perception towards NHs, especially hurricanes.

On the other hand, the people who feel more affected by Ophelia (≥ 4) do rank hurricanes more often under their top three than people who do not feel that severely affected (<4). It shows as well that not all parts of Cork were badly damaged, which could support the idea that people were expecting damage much worse and, in the end, were not much affected. This is also supported by the fact that especially people who stated that they were affected by property damage also rated their affectedness by Ophelia with a value larger than 4. If people rated their affectedness by Ophelia less than 4, they stated much less that they had property damage.

In addition, the low positive correlation (close to medium positive correlation) of affectedness by Ophelia and fear of the specific NH “hurricanes” in the future shows a similar picture. Here, there is a connection that higher affectedness leads to more fear of hurricanes in the future, even though there is only little correlation. Still, the linear regression shows that affectedness can only explain the dread of hurricanes in the future in a minor proportion. Thus, there might be other factors that lead to the fear of hurricanes in the future. Another factor that could lead to the concern of hurricanes in the future could be the awareness of climate change and its effects on NHs. One participant even ranked climate change beyond tipping point as the number three

NH he was fearing most. Still, more research is needed to explain what affects the fear of hurricanes in the future among the population of Cork.

These findings are in line with the fact that people do feel much more concerned about hurricanes in the future than they did fear them before Ophelia made landfall. There is a clear increase in concern among the people of Cork. This could as well be slightly explained by the affectedness. However, this could also be due to more awareness of climate change. Further, there was only one participant that rated that he would be less concerned about hurricanes in the future, all other participants had a higher or equal concern about hurricanes. The higher concern in the future could as well be induced due to recaptured memories of the event by the survey and thus the people were much more confronted with their fear than they would usually have been. Nevertheless, there have been much more remnants of hurricanes that affected Europe and especially Ireland, as shown in chapter 3.1.2. Consequently, the phenomenon of PTCs should not be new to the people of Cork. However, the most devastating hurricanes in Ireland before Ophelia were Debbie in 1961 and Charly in 1986, which both are a long time ago and people tend to forget relatively fast (CD & Fire Department, Joyce, Kearney, O'Brien, p.c., 2022), which could lead to a low fear of hurricanes before Ophelia made landfall and a higher ranking afterwards because the memory is refreshed.

However, if people fear hurricanes in the future (value of ≥ 4), they do not automatically rank them under their top three in the ranking of which NH they feel threatened by most. Yet nearly 2/3 rank them under their top four. But still, it is interesting that even though people fear hurricanes in the future, they are not under their top three NHs in the ranking.

On the other hand, people who fear NHs in general rank hurricanes more often under their top three NHs they feel threatened by most than people who do not fear being affected by NHs so much. Even though only 22 people rate their fear of being affected higher or equal to four, it is obvious that they rank hurricanes higher (54.5% vs. 35.7%). Though, if one compares if the participants who are concerned about NHs affecting them have been affected by NHs, still, most of them state “no” (8 yes vs. 17 no). If we further assume that experiences of NHs lead to less fear of them due to better knowledge of the hazard (Slovic, 1987), we can say that these results are supporting this statement.

Nevertheless, Cork is affected by NHs very often. As mentioned earlier, these are mainly floods and storms. There have been several more warnings for Cork since Ophelia and till the 17th of February 2021. There have been an additional 38 orange and red warnings for Cork and all these warnings were true and the hazard affected the county (Met Éireann, 2018a). Thus, it is difficult to believe that more than 2/3 of the participants of this survey have not been affected by a NH before. However, it is difficult to argue why people answered that way. A further study

could focus on the reasons why people were not considering their affectedness by Ophelia as being affected by NHs.

8.3. Change of Risk Communication

8.3.1 Rating of Improvement Suggestions

In general, people in Cork feel well informed about how to behave during Ophelia but less about the threats of it. When we look at the results of hypothesis five and the information in Table 7 about the mean value and the mode of the rating of the satisfaction about the information of the threats (4.27/ 5) and about how to behave (4.64/ 5) the information satisfaction becomes clear. More than half of the people ranked the value 5 or 6 for information about the threat and more than 2/3 did the same for information on how to behave. Thus, we can say that the people were satisfied with the information they received during Ophelia. Yet, even if they rated the question about behaviour and threat high, people were still suggesting some improvements in the content. They still wished for information on how to personally deal with and how to prepare for the impacts of the storm, in case of disruption in services, damage to property and the impacts that can be expected locally. Consequently, further impact description on how to react in case of occurring impacts and more reasons on why to behave like it is wished by the government would be useful to improve risk communication in the eyes of the population of Cork. Intriguingly, these wishes are in line with the suggestions experts proposed to improve risk communication. Hence, this improvement would benefit all parties involved in risk communication.

The experts ranked the suggestion to include information on behavioural advice into risk communication before the NH hits and advice on how to organise for impacts afterwards as their number one priority. Their second most important improvement is to have education and training for the citizens in Cork. This shows that the experts and the citizens of Cork have the same wishes for improvement, and it is not only focused on short-term risk communication before the hazard arrives but focuses on long-term communication together with training. Better preparedness that can result from communication and training is an important step in reducing vulnerability (Lazrus et al., 2012; MacIntyre et al., 2019). The experts as well voted highly for the change of weather forecasting to impact forecasting which too would satisfy the wish of the population of what to expect in which region of the country by NHs. Still, the people wished also to have advice on where to go in case their house is destroyed. There are no central buildings or shelters available in Cork (Kearney, p.c., 2022) and this improvement suggestion was only ranked 13 out of 14. Here a solution should be found where people can go in case their house is destroyed.

Even if the ranking gives a list of the most and least important suggestions it must be said that the experts had quite different opinions about the suggestions most important to them. Though the behavioural advice is voted mainly with the value one, two, and three, one expert voted here with the value nine. There are several such outliers in the ranking. Also, for the least important improvement suggestion “Have special security plans for livestock.” the ranks were 14,14,14,10, 1. This could be overcome next time by asking more experts to participate in the ranking. Here it would be interesting to see if similar institutions would rank similar and if this indicates that a better exchange between the institutions involved in risk management in Cork is needed, to have even more consensual communication in the future.

Even though these are good improvement suggestions, the aspects ranked as most important are already set in the FMEM. As described in chapter 3.3, the FMEM assigns tasks like planning and preparedness for times when no emergency is acute to the PRAs. It is stated that this involves the preparedness of the public through awareness raising of risks, as well as communicating risks, how to minimise them and what each person can do to protect themselves from such hazards (Department of Housing, Planning and Local Government, 2006). The need of education and awareness raising to adapt to the effects of NHs influenced by climate change is not only a result in this research with local experts involved in communicating the risk of Ophelia, this was also found in the study of Medway et al. (2022), who interviewed experts involved in risk management on local, regional and national level of Ireland about their awareness of climate change related risk. Ergo, as these suggestions are not in place yet, even though they should be already, it is time to create a proper plan on how to integrate these improvements into risk communication in Cork. Especially because these procedures are part of the best practice in risk communication as described in chapter 4.3 and can benefit the population and the risk management agency. Further, a participatory communication approach would also support the strategic goal 4 “Mobilise climate action in local communities” of the “Delivering Effective Climate Action 2030” report by the County and City Management Association (County and City Management Association [CCMA], 2019), such an approach is already implemented in Co. Mayo, where the farming community is authorised to be involved in emergency management of storms (Medway et al., 2022) as it was suggested by Mr Kearney (p.c., 2022), too.

Further, one could often gain the feeling that some of the communication during Ophelia was able to happen due to sheer luck, since the main emergency management institutions were not affected by power outages because they were operating in Cork City where the outages were only minor and mobile service stayed up. Often the interviewees were stating that communication with the crews was only possible because there was no loss of mobile service in Cork City (CD & Fire Department, Joyce, p.c., 2022) and that communication issues occurred everywhere where there was no mobile service due to lack of power and crews were relying on their mobile

phones or did not have enough TETRA radios for all teams (ESBN, Kearney, O'Brien, p.c., 2022). Resulting, crews needed to drive around till they got phone service somewhere (ESBN, O'Brien, p.c., 2022) or they needed to come into the main coordination centre (CD & Fire Department, ESBN, Kearney, p.c., 2022) so they could communicate with other teams or their supervisors. It was as well lucky, that it was the first time the communications team of the LCG was included in the structures of the LCC. If the communications team would have been at home, receiving information to disseminate to the public (as it was the case prior to Ophelia), most likely communication would have failed due to the prolonged power outages the communications team would have probably had at home. The communication in the LCC and the ESBN local coordination centre was not impacted due to their preparedness with generators. Only the crews restoring power lines outside of the ESBN office could not be reached due to reliance on the mobile network (ESBN, p.c., 2022).

Even though the power outages were very severe, the backup generators at mobile masts are voted only on to the 12th place in the ranking. This is surprising, as some institutions were relying on the mobile network to stay up, which did not happen, and huge communication shortages occurred due to prolonged power outages. Further, better power backups at mobile masts were also wished for by the citizens of Cork. Still, experts ranked the improvement to have enough TETRA radios available at rank six. This might be the alternative to overcome the network problems between the risk management institutions and they become more resilient. Though, ESBN introduced an App for their power restoration teams which is only working if mobile data is available. Consequently, in case of another storm like Ophelia, the App cannot be used if there is again a failure of mobile service because the backup generators might still not be powerful enough to support the masts till ESBN has the power restored. Also, the newly equipped emergency management room of the HSE has no generator in case of power outages. Thus, in case of disruption of power the use of the room would not be possible, as all the equipment requires power and communication to the pillars of the HSE will become extremely difficult as in Ophelia.

Hence, the issue of not being able to communicate with crews still exists but might be overcome partially, as some of the agencies now start introducing TETRA radios to all their crews. Before the LCC did not have any TETRAs and is only now introducing them into the emergency management of floods (Joyce, p.c., 2022). The representative of the fire department (p.c., 2022) stated that they did buy several power banks to prevent empty mobile batteries in case of power loss, however, the loss of mobile network cannot be overcome with this.

8.3.2 Use of Media

Even though there were severe power outages the used communication media changed only slightly during Ophelia for the people in Cork (Table 20 & Table 21). After landfall, fewer people were gaining info via TV and the valid percentage of people using radio and SM as a source of information increased. Especially SM was rising. This could be due to the power loss that happened in Cork and even short-term in Cork City. Particularly as most people participating in this survey were staying in Cork City, where power and mobile service were restored relatively quickly if at all affected and the generators at mobile masts could provide service till power restoration (Joyce, p.c., 2022). Further, radio is broadcasting local issues, advisories, and messages and RTÉ, as the main television programme provider, is focusing on the news on the national level. Thus, it is not surprising that the medium of radio increased, and TV decreased. It is only logical that printed newspapers decreased as a source of information as there was no delivery during the day of landfall and afterwards as all businesses were closed, and roads were blocked which made it difficult to deliver. Further, the percentage of people using online newspapers did not change before and after landfall. Interestingly one person stated that she received a warning by siren after Ophelia made landfall, even though Ms Cusack (p.c., 2022) stated that there are no sirens for submitting messages in Ireland. The used media by the citizens of Cork is in line with the communication channels used by the emergency management institutions to provide the public with information regarding the storm. They as well mainly relied on radio and SM during the event as local radio is very popular in Cork and the people demand to be informed about every development during the event which can be done fastest with proactive communication via SM (Joyce, p.c., 2022). The media used in Cork is in line with the media described under the best practice in chapter 4.3.

Still, it is not known if people who were affected by mobile and landline loss could still get a connection to the emergency number 112/999. However, there were some struggles in the emergency call centres themselves due to the number of incoming emergency calls. Yet, all calls could be transferred to the responsible fire brigades though sometimes it was difficult to reach the fire brigade volunteers as these voluntary stations were as well affected by power outages (CD & Fire Department, p.c., 2022).

Even though people are satisfied with the communication, there was the wish of some participants that the media broadcasts less alarmist if a minor NH is approaching to avoid warning fatigue. This is an interesting wish as it shows that the persons stating this might have experience with the phenomenon of warning fatigue, either being warning fatigue themselves, know people who are warning fatigue or are informed about the concept and try to prevent this from happening. This warning fatigue could as well come due to the vast number of warnings that are given for specific events and the warning process of Ophelia as well.

8.3.3 Warnings

After Ophelia happened several warnings were dismissed by Met Éireann for Cork. There have been 38 orange and red warnings and 154 yellow warnings till February 2021 (Met Éireann, 2018a). When it comes to the warning history during Ophelia communication between institutions seemed not as smooth as stated. There was some critique between the lines. Even though the first weather advisory was issued on the 12th of October which already triggered preparations in ESB and ESN, the red warning came in on Saturday 14th of October for the first counties (Galway, Mayo, Clare, Cork, and Kerry) and an orange warning for the rest of the country quite close to the predicted landfall of Ophelia. Still, this warning was already early and the first time since the introduction of the coloured-coded warning that a warning was issued 48h before an event (NDFEM, 2019). However, there have been a total of 16 warnings from Met Éireann regarding Ophelia within three days. Of these, ten were valid for Cork (five were including Cork directly and five were valid for all of Ireland) (Met Éireann, 2018a). Still, the national red warning came in place on Sunday, the 15th of October at 8 p.m. (NDFEM, 2019).

The sheer number of warnings together with the late national red warning was causing some challenges. As it was only quite sure that Ophelia would hit Ireland 24 hours before landfall, the NECG came together for a meeting on the morning of the 15th of October. The communication with the public started intensively from this time onwards together with mobilising all response capabilities. However, the advisories from the Department of Housing, Planning and Local Government, the Department of Education and Skills, the Department of Transport, Tourism and Sport and Bus Éireann were issued after that meeting on the 15th as well. Hence the activation of the severe weather protocol for homeless services, which ensures that homeless people get proper accommodation during the storm, as well as the information that all public transport will be cancelled in the areas with a red warning (which still were Cork, Kerry, Mayo, Galway, and Clare at that time) and that schools should decide locally if they should open during the storm or not came on short notice. Especially the Department of Education made the closure only obligatory in the afternoon of the 15th. Contacting all staff on a Sunday evening was a difficult task for many organisations (NDFEM, 2019). Especially since the red warning was issued for the whole country only on the 15th at 8 p.m. (Met Éireann, 2018a), the management in the other counties which were not included in the prior red warning was even more difficult to handle.

This late convening of the NECG made it very tough for employers to inform their staff on time. The late warning gives little time for preparation, neither for the chainsaw crews who were working in advance of Ophelia to clear old and damaged trees nor for the health service, the ESB, ESN and the CD. Mobilising staff or patients to come in early to their particular

health service is a challenge at this time of the weekend as well as mobilising volunteers of the CD and repair crews in ESB and ESNB. Yet, due to their expertise, ESB, ESNB and the health service did already start their preparations from the weather advisory (12th) onwards (ESNB, Hand, O'Brien, p.c., 2022).

Nevertheless, if we look at the objectives of this research, we can say that there was constant risk communication regarding Ophelia, starting in Cork as soon as the 14th of October by the red warning of Met Éireann, which triggered communication for all risk management institutions. Chapter 7 gives a detailed description of the development of the communication chain, content, and media during all stages of the event and their development afterwards. As mentioned before, people were very satisfied with the information they received during Ophelia and even if they wished for some improvements, these are in line with the improvements the experts also see as most important for Cork. If these enhancements in risk communication would be mainstreamed in the future, there would as well be a closure of the gap of not communicating about NHs while there is no direct threat of them. If the communication would start with education in schools on how to prepare oneself for NHs, it would reduce the vulnerability of the people in Cork to the impacts of any NH and increase their resilience. Especially if this is paired with impact forecasting and behavioural advice given in risk communication to only remind people of measures, they could undertake to protect themselves. The implementation of these activities would also be in line with the tasks the FMEM assigns the PRAs and enhance resilience and would follow the best practice examples of chapter 4.3. Further, the Irish government is promoting several campaigns for different seasons. As mentioned previously, there was the campaign “Be summer ready” this summer (Department of Defence, 2022a). Additionally, there was a campaign “Be winter ready” in the winter of 2021 (Department of Defence, 2022b). Both campaigns advise people on how to prepare for hazards occurring in summer or winter, respectively. However, there is no information about wind in either of these campaigns. This could as well be an option of introducing a “Be storm ready” campaign to raise awareness and preparedness among the citizens of Cork and the whole country. Moreover, the media should focus more on adaptation measures and not only focus on the recovery of past events, as also suggested by Medway et al. (2022). Given that the people in Cork are well aware of the risks of storms, floodings and hurricanes a campaign to increase preparedness together with education is a good opportunity to enhance resilience and have a population less impacted by the effects of hurricanes and/or storms. Particularly under the premise that storm and flooding are both associations with hurricane-related impacts.

9. Conclusion

This study aimed to show the risk perception of the people in Cork County towards NHs, especially hurricanes, as well as their satisfaction with the risk communication during Hurricane Ophelia by analysing the risk communication chain, content and media and obtaining improvement suggestions in communication, if necessary. To assess this, the perception of the people was analysed with the help of a standardised survey. The risk communication chain, content and media were evaluated with the help of expert interviews with professionals involved in risk management in Ireland. Improvement suggestions were extracted as well from the survey and the expert interviews and have been ranked by the participating experts according to their importance. An understanding of the risk perception of the people is a necessity to have a higher chance of successful risk communication. Depending on how people perceive a risk the communication needs to be adapted. Thus, it is important to know how risk is perceived as the approaching communication should be chosen accordingly.

While it could be shown that the people of Cork County are in general not much concerned about being affected by NHs, they still ranked storms, river floodings and hurricanes as the top three NHs they feel threatened by most, after Hurricane Ophelia hit the country. Before Ophelia made landfall, they only ranked hurricanes in the 8th place out of 8 possible choices of NHs. This shows that after experiencing Hurricane Ophelia the risk perception towards hurricanes changed immensely and people are much more aware of hurricane risk in Ireland. This is supported by further questions in the survey where hurricanes in particular are perceived as riskier in the future after the people of Cork were affected by Hurricane Ophelia in 2017. This perception is in line with the findings in the literature that PTCs will reach Europe, and particularly Ireland, more often in the future due to climate change and resulting warmer SST, a shift of the ET zone and less vertical wind shear.

While the risk perception of the people towards hurricanes is there, even though, they do not feel very affected by NHs in general, 2/3 of the people stated that they have not been affected by a NH in the past six years. Still, they were stating an affectedness by Ophelia. And due to the frequency of NHs affecting Cork, like river floodings, coastal storms and strong winds, together with the 154 yellow and 38 orange and red weather warnings Cork received since November 2017, it is not very likely that citizens have not been affected in any form. Despite their affectedness by Ophelia, the citizens of Cork were satisfied with the communication they received about how to behave and the threats the PTC posed to them. Still, they wished for better communication about how to prepare beforehand for impacts that could be caused by the storm and how to behave in case special impacts occur or where to go in case of serious property damage. Further, they would have liked to have an impact prediction on a local level in the best

case. These improvements are in line with the enhancement suggestions of the experts. They as well ranked the improvement suggestions of education in hurricane preparedness, to advise people how to prepare if an event is approaching, and impact forecast instead of weather forecast under their top three. However, experts also have discrepancies with the wishes of the population. They only ranked the necessity to have a central safe building on rank 13 out of 14. Further, the citizens wished for better mobile mast connection during the storm, which would also overcome the uncertainty if people were able to reach the emergency number 911/112. Yet, having larger generators at mobile masts was only voted on rank 12 by the experts, even though ESBN and the HSE are still relying on mobile phone service for their main communication with their teams. Even though the experts voted the suggestion of having a sufficient amount of TETRA radios available to rank 6, the TETRA radios could overcome the mobile issues internally. However, ESBN is now using a mobile app within their repair crews to report the recovery of damaged power lines. Nonetheless, reporting is not possible if there is no mobile internet connection. Still, there have been some discrepancies in the ranking of the experts and a high variety of assigned ranks to certain improvement suggestions.

9.1 Outlook and Recommendations

Due to the mentioned discrepancies, it would be interesting to see if similar institutions would rank similar and if this indicates that a better exchange between the institutions involved in risk management in Cork is needed, to have even more consensual communication in the future. Moreover, the ranking here is neither considering the implementation time or costs nor the number of staff needed for implementation. Additionally, it would be interesting to analyse the reason people do not feel affected by NHs in the past six years, even though there were many severe weather events since 2017 and people stated that Ophelia has affected them. Here further studies could be of advantage. Moreover, the influence of the place of stay during a NH on the perception could be researched further, as people not in Cork were perceiving a higher risk of hurricanes than the ones staying in Cork during Ophelia. Also, more research on the effects that lead to more fear of hurricanes in the future among the citizens of Cork would be of interest, as affectedness can only explain future fear by 8.8%.

Still, it is important to overcome the gap in preparedness among the population to reach better resilience among the people in Cork. This can be done through education which starts in school, through awareness-raising campaigns, like the Department of Defence already promoted for temperature-related hazards and through a deeper engagement between risk management agencies and the public. As there was some critique found in inter-agency communication about timing and reachability during the event as well as in intra-agency communication due to loss of mobile connection, it would be advantageous to have an assessment of satisfaction to see if

the communication internally, between the different institutions, and with the public was of success. Thus, frameworks on how to assess performance, preparedness, and new improvements in communication would be of benefit, especially as the active involvement in risk communication of the public is stated in the FMEM.

In conclusion, this study shows that to develop and assess risk communication programmes, risk perception studies are essential. Through the assessment of the people's perception, one can analyse how deep into the topic the communicator needs to go and it can be obtained what the people of Cork wished for in communication. As effective communication depends on understanding the issues that the intended audience has, it is important to use the wishes of the population as a trigger to engage them in communication. Moreover, research on risk perception aids communicators in locating areas of disagreement or scepticism. They can identify situations where there is a lack of credibility or trust and offer more potent solutions for regaining lost confidence. Although they cannot ensure that risk communication will be successful, the conclusions from research on risk perception can help these organisations create communication campaigns that are more effective and efficient, particularly if they involve public participation and exchange, as it is stated by best practice examples. Workshops, exercises and participatory management could benefit the risk communication between agencies and the public but also between the agencies, especially as some experts were acknowledging that community development in times of COVID-19 is progressing and communities should be involved in the communication, management and wrap-up of hurricane risk. This engagement can become crucial with the effects of climate change leading to a higher probability that hurricanes undergo ET and affect Ireland and Europe, in general, more frequently. If this happens, the possibility of destructive winds, large amounts of rainfall and high storm surges are increasing as well. Hence, these risks should be addressed in the exchange between public and risk management institutions and should be part of a risk communication that makes the people of Cork more resilient to hurricanes and their associated effects.

10. References

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11. Annex

Annex 1 – Survey Questionnaire

Risk perception and communication of natural hazards

Dear Sir or Madam,

This poll is part of a Postgraduate Research project from the TH Köln – University of Applied Science in Cologne, Germany in cooperation with the University College Cork (UCC). I am Ines Koensgen, studying Integrated Water Resources Management in Cologne and the topic of this research are natural hazards in Ireland. A natural hazard is a natural phenomenon that might have a negative effect on people or the environment. As I have experienced some natural hazards during my former stay at UCC in Cork I want to dedicate my studies to this topic and the improvement of its handling. This survey contains questions on risk perception concerning natural hazards by the citizens of County Cork, as well as about risk communication in the County. The focus group of this survey are the citizens of Kinsale and Cobh. The survey will approximately take you 10 – 15 minutes to complete. Feel free to share this poll with your family and friends! The more people answer the survey the better the results. Thank you very much in advance for your collaboration.

Section 1 – Natural Hazards

How afraid are you of natural hazards affecting you?

The ends of the scale show the opposite feelings, as closer you are to one end as more you feel related to that feeling, as further away you are as less you feel related to that feeling. Please mark only one tickbox.

I don't feel afraid I feel afraid

Have you been personally affected by any natural hazards in the past 6 years?

Yes No

If so:

What is the natural hazard that first came to your mind that you have been affected by?
.....

Which natural hazard, that occurred to you, was the most devastating one in your opinion?
.....

If you read the following hazards that occur in Ireland which one would you consider the one that you feel threatened by most?

Please rank from 1 to 8, where 1 is the hazard, you feel threatened most and 8 where you feel threatened the least. In case the hazard you fear most is missing please write it down under "other" and rank from 1 to 9, where 1 is the hazard, you feel threatened most and 9 where you feel threatened the least.

___ River Flooding

___ Drought

___ Heat Wave

___ Storm

___ Hurricane

___ Coastal Flooding (storm surges)

___ Wildfire

___ Landslides

___ Other, namely:

Do you think you would have ranked the natural hazards mentioned before differently prior to Hurricane Ophelia?

Yes No

If so:

How would you have ranked the natural hazards before Hurricane Ophelia?

Please rank again from 1 to 8. (1 is the hazard, you feel threatened most and 8 where you feel threatened the least). In case the hazard you fear most is missing please write it down under "other" and rank from 1 to 9, (1 is the hazard, you feel threatened most and 9 where you feel threatened the least).

- ___ River Flooding
- ___ Drought
- ___ Heat Wave
- ___ Storm
- ___ Hurricane
- ___ Coastal Flooding (storm surges)
- ___ Wildfire
- ___ Landslides
- ___ Other, namely:

Section 2 – Hurricane Ophelia

How affected were you by Hurricane Ophelia which hit Ireland in October 2017?

Please mark only one tickbox.

Not affected Very much affected

How were you affected?

Please choose from the following options by ticking the boxes. You are allowed to mark several boxes.

- I was injured during the storm
- Family members were injured
- Neighbours/ Friends were injured
- Damage to property
- Loss of property

- Damage to cars/ other vehicles
- Prolonged disruption of power supply
- Prolonged disruption of water connection
- Prolonged disruption of internet connection
- Prolonged disruption of mobile phone service
- Prolonged disruption of landline phone service
- Other, namely:
- I was not affected

How concerned were you about hurricanes hitting Ireland before Ophelia made landfall?

Please mark only one tickbox.

Not concerned Very much concerned

After you experienced Ophelia, how concerned are you that hurricanes will affect Ireland more often in the future?

Please mark only one tickbox.

Not concerned Very much concerned

Section 3 – Risk Communication

How informed did you feel about the threats of Hurricane Ophelia?

Please mark only one tickbox.

I didn't feel informed I felt well informed

How informed did you feel about how to behave during Hurricane Ophelia?

Please mark only one tickbox.

I didn't feel informed I felt well informed

What kind of information did you wish you had received during the event that was missing in your opinion?

Please write below.

.....

How did you receive information about Hurricane Ophelia before it made landfall?

Please choose from the following options by ticking the boxes. You are allowed to mark several boxes.

- Television
- Radio
- Newspaper (printed)
- Newspaper (online)
- Sirens
- Neighbours/ friends/family
- Social Media
- Smartphone Applications, like Met Eireann
- E-Mail
- Other, namely:
- I did not receive any information

How did you receive information about Hurricane Ophelia after it made landfall?

Please choose from the following options by ticking the boxes. You are allowed to mark several boxes.

- Television
- Radio
- Newspaper (printed)
- Newspaper (online)
- Sirens
- Neighbours/ friends/family
- Social Media
- Smartphone Applications, like Met Eireann
- E-Mail
- Other, namely:
- I did not receive any information

Section 4 – Personal Information

Which age category are you in?

- ≤15
- 16-30
- 31-45
- 46-60
- 61-75
- >75

Which sex are you?

- Female
- male
- diverse

In which town/city were you staying during Hurricane Ophelia?

Please write below and also mention the county.

.....

In which town/city are you living today?

Please write below and also mention the county.

.....

Below you find a voluntary field which you can use in case there is anything else, regarding risk communication of natural hazards, that appears important to you but was not part of this survey. If you want, you can address that here.

.....
.....
.....

You have reached the end of the survey. Your data will be handled anonymously, no data will be handed over to second or third parties.

I want to thank you for your time and effort in completing this poll and I hope you enjoyed your little excursion on the topic of risk communication and risk perception of natural hazards with focus on hurricane Ophelia.

For feedback, queries, comments and/or information about the results please feel free to contact me via: ines_martina.koensgen@smail.th-koeln.de

Annex 2 – Survey Results

Table 15: Absolute and relative frequencies of survey questions with rating

	1	2	3	4	5	6
Fear of being affected by NHs	19/ 21.3%	30/ 33.7%	15/ 16.9%	19/ 21.3%	6/ 6.7%	0/ 0%
Affectedness through Ophelia	14/ 15.7%	21/ 23.6%	18/ 20.2%	21/ 23.6%	11/ 12.4%	3/ 3.4%
Concern about hurricanes in IE before Ophelia	35/ 39.3%	24/ 27.0%	13/ 14.6%	11/ 12.4%	5/ 5.6%	1/ 1.1%
Concern about hurricanes in IE in the future	6/ 6.7%	9/ 10.1%	21/ 23.6%	17/ 19.1%	23/ 25.8%	13/ 14.6%
Information satisfaction about threats of Ophelia	5/ 5.6%	9/ 10.1%	9/ 10.1%	17/ 19.1%	32/ 36.0%	17/ 19.1%
Information satisfaction about behaviour during Ophelia	1/ 1.1%	4/ 4.5%	14/ 15.7%	13/ 14.6%	32/ 36.0%	25/ 28.1%

Table 16: Statement of participants about "Other" NHs they fear and would like to rank

Statements to the question "In case you ranked "other" in the ranking before. Which hazard were you thinking of?"
Things less likely like earthquakes/tsunamis etc.
earthquake
The unknown ones
Climate step-change beyond tipping point
Dam failure
Tsunami or Epidemic
House being hit by lightning- happened to neighbour, house destroyed
Wasn't thinking of anything but had to rank it somewhere, presumably.
Flash flooding of my home from heavy rainfall as opposed to river overflow
Disease
Infections - Pandemics
Wind turbine blades blowing off
River flooding due to human negligence (Inniscarra Dam in Cork e.g. November 2009)
Tsunami
Radon
Crop failure
Tsunami

Table 17: Statements of hazards that people have been affected by

Statements to the question "What is the natural hazard that first came to your mind that you have been affected by?"
Snowed in with no electricity or water for several days. Storm Ophelia small amount of wind damage.
Storms - high winds, red alert warnings from Met Éireann and closures of schools and work-places
flooding - where I worked
Landslide
Flooding due to storm

Continuing Table 17

Statements to the question “What is the natural hazard that first came to your mind that you have been affected by?”
Storms
2020, storm damage
floods
Storm/wind
Storm
Hurricanes & Storms
Flooding
COVID-19
Storms
Hurricane in Florida
Home flooded due to frozen pipes (icy weather).
Extreme weather
Flooding
heavy snow
Gale force storm
Hurricane Ophelia, Storm Emma (flooding, power outage, cut off from road network etc)
Storm Emma
Hurricane Katrina
Storms (e.g. Darwin, Ophelia), Storm surge and coastal flooding
Tree fell on house (minor damage) in a strong storm. Flood water and roof damage in different storm. Local roads cut off due to localised flooding.
Hurricane
Storms

Table 18: Statement of participants about the most devastating NH they have experienced

Statements to the question “Which natural hazard, that occurred to you, was the most devastating one in your opinion?”
Snowed in with no electricity or water
Storm Ophelia, I think.
hurricane on holidays Caribbean
Landslide
Flooding
We had trees down during a storm. But I don’t live in the city. The flooding over the past ten years has been devastating
2010
floods
Storm/wind
Storm
None
Flooding
devastating would be too strong a word - it was not devastating
Flooding
Hurricane
Home flooded due to frozen pipes (icy weather).
Flooding
Flooding
snow, and heavy winds, kept me at home
Excess rain damage

Statements to the question “Which natural hazard, that occurred to you, was the most devastating one in your opinion?”
Hurricane Ophelia
Storm Emma
Hurricane Katrina
Storm Darwin
Strong wind damage for surrounding large old trees
Hurricane
I haven't been impacted by devastating hazards, but I have found with the frequency of storms my fear rise. I usually commute by foot or bike and have almost fallen over and been injured during these storms.

Table 19: Absolute and relative frequencies of how people were affected by Ophelia

Valid	Frequency (F)	%	Valid % (V%)
Neighbour/Friend injured	2	1.0	1.1
Property damage	33	17.2	17.5
No power	39	20.3	20.6
No water	14	7.3	7.4
No internet	32	16.7	16.9
No mobile service	16	8.3	8.5
No landline service	10	5.2	5.3
Other	17	8.9	9.0
Not affected	26	13.5	13.8
Total	189	98.4	100.0
Missing			
-99	3	1.6	
Total	192	100.0	

Table 20: Absolute and relative frequencies of how people received information before Ophelia made landfall

Valid	F	%
TV	69	23.3
Radio	46	15.5
Newspaper (online)	36	12.2
Newspaper (printed)	11	3.7
Sirens	0	0
Neighbours/Family/Friends	30	10.1
Social Media	39	13.2
Apps	35	11.8
E-mail	27	9.1
Other	3	1.0
No information	0	0
Total	296	100.0

Table 21: Absolute and relative frequencies of how people received information after Ophelia made landfall

Valid	F	%	V%
TV	59	22.3	22.5
Radio	47	17.8	17.9
Newspaper (online)	32	12.1	12.2
Newspaper (printed)	5	1.9	1.9
Sirens	1	0.4	0.4
Neighbours/Family/Friends	31	11.7	11.8
Social Media	43	16.3	16.4
Apps	30	11.4	11.5
E-mail	11	4.2	4.2
Other	2	0.8	0.8
No information	1	0.4	0.4
Total	262	99.2	100.0
Missing			
-99	2	0.8	
Total	264	100.0	

Table 22: Statements of "Other" media used to receive information about Ophelia before and after it made landfall

Statements of the people who chose "Other" in the questions How did you receive information about hurricane Ophelia BEFORE (B)/AFTER (A) it made landfall?"	
B	Text messages from the Emergency management team at my workplace
B	Text message from work.
B	University and Local Government Warning Systems
A	Text messages from my employer
A	Walking around and surveying damage

Table 23: Statements of what information people wished to have received about Ophelia

Statements to the question "What kind of information you wished you had received during the event that was missing in your opinion?"
How to access essential services. Assistance in same.
What to do if house destroyed and have nowhere else to go etc.
I feel the information shared was sufficient, however as I was unconcerned, I did not pay too much attention until it was clear that Ophelia would impact Ireland
What is the safe and correct thing to do if a certain situation occurred e.g., water supply lost
How mild it was in land
Re connection of power
What separates this event from a normal "bad" winter storm
More accurate damage expectations per area
I can't remember! Maybe communication about what emergency services were available locally.

Statements to the question “What kind of information you wished you had received during the event that was missing in your opinion?”
Safety instructions, how to prepare etc.
List of things to do to protect yourself during a hurricane
Nothing more, in cork we were preparing a few days beforehand due to the clear messaging from the state
I didn't pay attention to coverage as closely as I was out of the storm path, but I would expect something close to USA style round the clock coverage for the duration of the storm over TV and radio, especially as things can change fast when it hits. I have experience of riding out and running from a Hurricane in USA (South coast 2005).
I was planning on driving up to Dublin the morning of. Everyone was treating it like a bad storm, so it wasn't until very late at night that everything fortunately got cancelled. Otherwise, we would have been expected to carry on as before.
Early warning where possible and up to date services (power, water etc) updates.

Table 24: Statements of the voluntary field where people could raise anything related to risk communication of NHs that was not part of the survey

Statements to the question “Is there anything else, regarding risk communication of natural hazards, that appears important to you but was not part of this survey? If you want, you can state this here.”
Survey very focused on Ophelia
Leaflet drops prior to the event by An Post, in particular, as elderly people, especially in rural areas, were not prepared for it. One uncle suffered a collapsed roof whereby he knew of an issue but didn't know the storm would accelerate damage. If something were communicated re safeguarding of person, property, access to services, supports etc with numbers etc in a handy leaflet or one page, it may have circumvented this. We could have fixed the roof ourselves (as we have family in the building trade) beforehand, as this collapse happened in the room, he sleeps in.
Need for urgent adaptation, rather than slow policy evolution at minimal political cost. Clear communication of greater cost of inaction or inadequate action. Public consultation then timely, clear communication of how social equity will be maintained or strengthened as adaptation progresses
I think that as climate change becomes a more prominent issue Ireland will most likely face natural disasters we would never have in the past. As it stands, I feel like we have a good infrastructure to deal with these disasters, but it is definitely preventable
tsunami here in 1942 and 1835 - there is no plan or preparation for the next one
Some smaller storms are overplayed on media, making people immune to the news if a large storm is coming
Radon Gas

Statements to the question “Is there anything else, regarding risk communication of natural hazards, that appears important to you but was not part of this survey? If you want, you can state this here.”

Communication of dangers of flooding in 2009 was extremely poor. People were advised of the risk of flooding but not of the EXTENT of it (those living in basement flats were lucky to escape with their lives). If more information had been communicated, people could have made better arrangements to prevent damage.

I feel that the media needs to find a balance between alarmist/ sensationalist/ incessant reporting against factual/ common-sensical reporting. Whipping people into a frenzy serves no purpose and detracts from a serious issue which may occur.

I don't believe storm Ophelia was a hurricane. It was a hurricane formed over the Atlantic and when it reached Ireland it was considered a tropical storm

I was living in Christchurch New Zealand in 2011 when the earthquake struck, so I find the natural hazards that affect Ireland less fearful than I may have felt if I had not lived in a country subject to earthquakes and tsunami warnings.

The yellow-orange-red hazard warning system Met Eireann use is very easy to understand, and after a while you get used to the idea that yellow is a normal bad day, and orange/red are really dangerous, and you need to take precautions. It should be used for all the hazards in this survey, not just the storms

The communication of uncertainty in predictions is important; the public should understand that predictions are often inaccurate and that this informs some of the decisions re: what is communicated.

We did not realise that we would lose our landline quite quickly due to the power outage, even with an old non digital phone. There are not sufficient power backups at the relay stations, so communication is impossible except for car radio.

There could be an aspect of how new to people the communications were. To have government and all relevant authorities giving briefings for the first time on an event really made folks listen, as it highlighted how serious this could be. Particularly when politicians stick their necks out, you know it's serious as they barely commit to anything.

Twitter is a fast and effective communication platform. I regularly use Cork Safety Alerts for hyperlocal emergency/ traffic information.

This happened in my first year in Cork, where previously I had been living in Texas. The infrastructure for extreme weather in Texas was much more transparent and effective, meaning it made Ophelia seem very insignificant, when actually it was very serious.

Best wishes for your research study.

I stay at home if there are weather hazards announced

Communication is key to help ensure we are well prepared before a storm, or a negative event occurs. Japan is a good example where they have numerous systems in place to alert its citizens of tremors or tsunamis.

Each type of natural hazard may need its own early warning system to help protect the wider population.

Annex 3 – Interview Questionnaire

Technology
Arts Sciences
TH Köln

Questionnaire for Experts



General Info for myself:

Date and Place of Interview:

Name of Interviewee:

Preferred Mentioning in Thesis:

Risk communication chain and content

1. Please explain the risk communication chain you are part of and the tasks with which you are charged.

Who are you receiving information from?

Are you generating any information?

Which information do you transfer and to whom?

In case you give information to several people/institutions: Is the info content the same?

Thresholds

2. When did you start communicating about the risks of Ophelia?

Were there any thresholds that were reached to initiate any communication action?

Which thresholds did you have while acting during Ophelia? (Track, Wind speed, expected wave height/ storm surge)

Media for communication

3. Which media did you use for communication?

4. Were there differences in the media used during the different stages of the event (before, during, after)?

During Ophelia, 150,000 customers were without broadband, mobile and phone service. How did you keep these people, that had no connection, informed about the status quo of the event? Especially in Co. Cork, 51,000 customers were without service even longer.

Lessons learned

5. Was there any need for change in the risk communication chain or in thresholds or in communication content after you experienced the communication before, during and after Ophelia?

There have been deaths because people wanted to clear fallen trees by themselves. Did you inform the population about handling such scenarios?

Would you consider giving guidelines of action on how to handle impacts that could arise during the storm, like how to handle fallen trees, flooded basements, interrupted power lines, etc.?

6. What were your lessons learned about the event and its communication? Would you communicate differently the next time?

Annex 4 – Code Categories and their Content

Table 25: Summary of all code segments of the interview with Mr Kearney

Code\ Interviewee	Mr Kearney, Civil Defence Officer County Cork South
Risk Com. chain	
<i>Intra-Agency</i>	<ul style="list-style-type: none"> ○ we made up our own structures locally because we could see on-site what needs to be done and dealt with and we know our resources and use them effectively. ○ volunteers in Kinsale took the initiative and went out to help, ○ John Kearney gets information from his operational team ○ This happened within their own social network in CD.
<i>Inter-Agency</i>	<ul style="list-style-type: none"> ○ There is a management team in Dublin. They get together when events are coming. Under the national team, there are sub-management teams throughout the country. There will be one in Cork City that deals with the mainstream services for Co. Cork and Co. Kerry and communicates with the Civil Defence (CD) Office in Kinsale. ○ in Kinsale they used TETRA to communicate with the sub-management team in Cork ○ made sure, that people could get to their dialysis by communicating with the hospital staff and his people out in the field. ○ talked to management people; People of the rescue management, like garda, would contact Mr Kearney with issues they cannot fulfil or handle at the moment. So, if people call the police the police will inform Mr Kearney and he can get out. ○ Garda calls him through TETRA ○ Interagency meetings are held regularly
<i>Public</i>	<ul style="list-style-type: none"> ○ Communication with the local people happened ○ Talk to communities personally ○ marine band to communicate with ships ○ the CD is not communicating to the public with social media, because they are on the field and don't handle communication then. ○ He would only dispatch the crews that are on standby according to the importance of the incoming calls. Afterwards getting information back from the teams and himself and then spoke to the control centre in Dublin which has automated control of the switches of the local networks.
Risk Com. Content	
<i>Intra-Agency</i>	<ul style="list-style-type: none"> ○ For safety, they allocated areas where the staff would gather beforehand and that were predicted to be affected worse. ○ Main communication happens before, but to staff, less to people. Communication is important to be prepared to act when the event is hitting.
<i>Public</i>	<ul style="list-style-type: none"> ○ The only thing they communicated then was that people going to these areas will not be rescued by the emergency Services and the CD. ○ they decided to warn people very early to get a higher lead time ○ government closed schools and workplaces and public buildings. ○ warning system in Met Éireann (yellow, red weather status)

Continuing Table 25

Code\ Interviewee	Mr Kearney, Civil Defence Officer County Cork South
Public	<ul style="list-style-type: none"> ○ The latest 24 hours before the event the forecast of intensity, direction, etc are very accurate and then the information is also going up and down in all the media. ○ neighbours were asked to make sure their neighbours are all right or if they need assistance. This was communicated beforehand, so communication in advance is very important. ○ There was no content in communication on how to behave in case of emergency ○ There has not been any advice on the media (news, TV) on how to behave in case of emergency or give advice to check the first aid kit and that there is water in the house or cans with food etc. Only the advice not to go out. There was no information given about why you shouldn't go out.
Thresholds for Communication	<ul style="list-style-type: none"> ○ 2-3 days before the event happened there was a meeting within the CD. ○ operation and management of the event can plan accordingly to weather status. ○ The latest 24 hours before the event the forecast of intensity, direction, etc are very accurate and then the information is also going up and down in all the media.
Com. Media	<ul style="list-style-type: none"> ○ The local radio was broadcasting ○ TETRA ○ Talk to communities personally ○ local radio broadcast ○ marine band to communicate with ships
Before	<ul style="list-style-type: none"> ○ communication networks (mobile, broadband, landlines) ○ The latest 24 hours before the event the forecast of intensity, direction, etc are very accurate and then the information is also going up and down in all the media. ○ Social media was used before the power was off.
During	<ul style="list-style-type: none"> ○ in Kinsale, they used TETRA to communicate with the sub-management team in Cork ○ he relied on the resources that he had, which were TETRA and social local networks in the area of Kinsale ○ So, TETRA and personal communicating were the only options for communicating. ○ via the local radio station or by directly talking to people
After	
Changes in Com. Chain	<ul style="list-style-type: none"> ○ after the event, there was no coming together to talk about the failure and improvements. The learning has not evolved from it, at least not as well as it should.
Before	<ul style="list-style-type: none"> ○ Improvement of the warning system in Met Éireann (yellow, red weather status) makes people know what they have to expect, and warnings can be issued very early. Also, the operation and management of the event can plan accordingly to weather status.
During	<ul style="list-style-type: none"> ○ However, in Ophelia, the communication failed because the communication networks (mobile, broadband, landlines) were all down. ○ however, only most of them worked and they were not used very often and there was no communication between the mainstream services and a lot of support agencies.

Continuing Table 25

Code\ Interviewee	Mr Kearney, Civil Defence Officer County Cork South
<i>During</i>	<ul style="list-style-type: none"> ○ So, because of the failure in communication, we made up our own structures locally because we could see on-site what needs to be done and dealt with and we know our resources and use them effectively. ○ failed so he relied on the resources that he had, which were TETRA and social local networks in the area of Kinsale, popping into the office to get instructions ○ no communication reaching him from the top level ○ local networks were more effective than the ones before ○ it was down to individuals who stepped up and bring their leadership roles in to keep mobilizing the resources on the ground. ○ During the event, the CD cannot communicate with the people because they are busy. ○ Mr Kearney involved farmers in the helping crew because with their heavy machinery and special tools they could remove trees from the street, could drive around obstacles and difficult terrain, they know the area better than anyone. So, he used the farming community to supply medication to areas. ○ Mr Kearney only went to one farmer and asked for help and this farmer would inform the others in the area. ○ The problem is not communication from national management in Dublin to the county level but the communication between county and local operating units because the county cannot deal with the amount of information reaching them ○ Communication was very fragmented when the storm hit. This resulted in “people making poor decisions due to poor communication”
<i>After</i>	
Changes in Com. Content	
<i>Before</i>	
<i>During</i>	
<i>After</i>	
Changes in Thresholds	<ul style="list-style-type: none"> ○ Thresholds were fine no need for improvement preparations were accurate.
Improvement Suggestions	<ul style="list-style-type: none"> ○ In his experience, the community is always happy to help and support. However, they are rarely seen as a beneficial resource in emergency management, and he wants to change that. ○ Include them in emergency management and provide a little bit of training and they would love to be part of that. It would also become more attractive to the farmers to help if they would be nationally recognised because if their machinery is damaged during helping actions they do not get any refund for repairs and it is not covered by insurance. It would also reduce costs as there is no necessity to buy new vehicles with tax money, if the equipment is already in place, through farmers. ○ the county cannot deal with the amount of information reaching them and this should be improved.

Code\ Interviewee	Mr Kearney, Civil Defence Officer County Cork South
Improvement Suggestions	<ul style="list-style-type: none"> ○ Put a power generator in each community hall throughout the country to create a place where people can shelter, get hot drinks, food and warmth if there is no power in their houses. A place that everybody knows and is easily reached. There also water bottles could be delivered too and they could be handed out there, so households mustn't be visited individually by the helpers. ○ People should generally prepare better for these kinds of events because they happen regularly and will become even more frequent in the future. ○ Really good assets in the country however, they are their own parties. And not coordinated together. Something like the FEMA (Federal Emergency Management Agency) in the USA would be a good option, an organisation bringing together the knowledge and coordinating the actions and improvements of all the asset "castles". ○ There was no content in communication on how to behave in case of emergency. So that could be an improvement. ○ Also, people should have an emergency kit in the house, ○ regular training would make sense on how to behave in case of emergency. This should start in school. So, the kids will teach the parents. There should be a change in the education system to include this in the schools. Mr Kearney did teachings in school already for water security, like the behaviour on boats. But it should be more frequent and nationwide. Especially because children ask a lot of questions and bring the knowledge home. ○ There was no information given about why you shouldn't go out. This should be communicated Mr Kearney said because people react better to things where they can understand the risk better (debris flying like missiles, info that people might not be rescued due to overstretching of the system).
General lessons learned	<ul style="list-style-type: none"> ○ sometimes people working in hospitals could not be reached in case of emergency or could not reach their workplace because of damages to property, blocked streets, own issues, high risk. ○ a lot of confusion amongst management authorities, helpers and the open public, due to the failure of the communication structure. ○ treatment in the hospital failed due to power loss and a shortage of staff. ○ Communication from a central point does also not work because they were so inundated that they could not cope with the volume of communication that had come to them, or in the end, did not come anymore ○ problems in place that no communication reached him about. Roofs were coming off, trees were falling, and tornados with debris were causing damage. ○ jeeps of the CD were used to take people to hospitals because ambulances could not pass streets anymore. ○ The problem with local radio, you can only get a fraction of people, there must be a radio and the radio must be on. So that is not the best way to communicate. ○ The CD does not have a generator in their Kinsale office, in case of power loss. Water bottles need to be handed out. Further, the supply chain in Ireland is very tight, after 3-4 days the shelves, start emptying. Which is as well a thing that can cause panic in the communities. Especially bread is gone fast, after 1-2 days.
Challenges	

Continuing Table 25

Code\ Interviewee	Mr Kearney, Civil Defence Officer County Cork South
Other NHs	
Characteristics causing impact	
Info about LCC	

Table 26: Summary of all code segments of the interview with Mr Joyce

Code\ Interviewee	Mr Joyce, Director of Operations, Cork City Council
Risk Com. chain	
Intra-Agency	<ul style="list-style-type: none"> ○ Since 2015/2016 we would have a communications team included in the crisis management team (CMT) during the event. They are part of the local coordination centre (LCC). ○ David Joyce is the manager of the event. He would have a team of 5-6 senior engineers and senior staff underneath him, like the head of parks, the head of traffic, the head of roads head of environment, head of water and drainage. Because you could have blocked water pipe or a blocked gully and roads flooding. They would manage different tasks of the event and every event is different. <p>Cork city was lucky because communication came back very quickly and the outages were more in the countryside, but the LCC is responsible for cork city, not for the whole county. Ergo there was no concern about how to communicate with people who might not have their power back.</p> <ul style="list-style-type: none"> ○ Additionally, the communication team would skim through SM, especially the own channels of the CCC to see if people would have posted any issues arising, like fallen trees. This information would then be compared with the incidences recorded in the call centre and added if it was not reported yet. The information manager in the call centre would then collect the incoming posts and calls about a certain tree and give the collected information to the emergency managers, so David is not getting the same info 10 times.
Inter-Agency	<ul style="list-style-type: none"> ○ call centre people and information managers, who will feed the senior team with information and bring the information back. And there is the crisis management team in the big room which has the SM people included. And they would work closely together with the 8 people in the information room and double check incidents they found posted on SM and compare them with the incoming calls via the emergency number that is available (see more info later). ○ For that event, the LCC had 24h available phone contact with forecasters of Met Éireann, so there was the possibility to ring them whenever the team needed updated information on the movement of the storm (speed, track). Thus, David and a Team would evaluate all the information before the decision would be made so that the staff can move out again. ○ the LCC was calling for the help of the local army to clear the roads that were blocked due to the vast amount of fallen trees (500) ○ they get information on forecasts from Met Éireann and were in contact with them every 2hours or even in shorter intervals The information was also given to the LCC during scheduled times and then there was still the possibility to call the duty forecaster in case more information was needed. There was no such case during the event, that a duty forecaster could not answer the phone, so staff was adequately on duty for that event.

Code\ Interviewee	Mr Joyce, Director of Operations, Cork City Council
Inter-Agency	<ul style="list-style-type: none"> ○ If flooding would be expected due to the storm the LCC would get information from the Office of Public Works. They run the tidal gauges and are responsible to monitor coastal floodings for the entire country. ○ they get info from the Electricity Supply Board (ESB) ○ The major decision makers were David Joyce, the head of parks and the building manager, as due to Ophelia a lot of roads were blocked, trees were down and buildings were damaged. If the power would have been gone in the city what would have come into place would be the garda, the army and the civil defence. So, the LCC could have called the army in and made them visit remote places that didn't have power and assist them or provide information to them. But the first people that would have been called would be the civil defence (a volunteer organisation associated with local authorities). These are volunteers who are trained to do the task of civic responses. However, they have limited capacity. So, the next step of the protocol is to mobilise the garda if they are available. But again, if this is an emergency the chance that the garda is dealing with other emergencies is high. Resulting we would as a third step request the army from their barrack in the north of the city. They have 15 4WD so they can get to remote areas. And of course, we are in contact with ESB throughout the event
Public	<ul style="list-style-type: none"> ○ during an event they are part of the crisis management and have the task to push messages, given to them by the CMT to the public. ○ Another important part of the LCC is the group of people that are only designated to take phone calls from the public on a special dedicated emergency number. ○ They are monitoring what the management team is doing and getting the information out to the public. ○ He would only dispatch the crews that are on standby according to the importance of the incoming calls. Afterwards getting information back from the teams and himself and then spoke to the control centre in Dublin which has automated control of the switches of the local networks.
Risk Com. Content	
Intra-Agency	<ul style="list-style-type: none"> ○ They are producing their own information, like tides and the current status of the tides and sea. ○ tying down tiles and securing cranes, cutting down old or damaged trees. However, close before the start of Ophelia it was communicated to the forepersons of the teams to come back to the basis. The only service that was allowed out was the fire service, however, they were only allowed to move out, when there was a threat to human life. E.g., if somebody would call and tell that a tree fell on their car, but the person was not the insight of the car, the fire service would postpone the clearance till after the storm. ○ the biggest effort was made in finding trained chainsaw crews. Trees that were blocking the roads were prioritised, while trees on cars and properties were left for the clean-up from the 17th onwards.
Inter-Agency	<ul style="list-style-type: none"> ○ information was also given to the LCC during scheduled times ○ the LCC would get information from the Office of Public Works (OPW). They run the tidal gauges and are responsible to monitor coastal floodings for the entire country. ○ This is mainly due to the 2 dams located at the west of the city and in certain circumstances they need to release water so the dams are not overtopped, which can cause fluvial flooding. ○ During Ophelia, there was no release of water necessary. Ergo there was no real engagement with the ESB or the OPW during Ophelia. ○ see who was without power and when is the power estimated to be back on

Code\ Interviewee	Mr Joyce, Director of Operations, Cork City Council
<i>Public</i>	<ul style="list-style-type: none"> ○ The message would mainly include updates on a change in the situation of the event. ○ They were lucky that Met Éireann called a red warning early that morning which is equivalent to the fact that nobody is allowed on the streets. ○ In terms of communication, the initial communication of this was naming all the roads that are currently blocked and then informing people about roads that are reopened again. ○ not only CCC was saying this, but it was a national warning and the national major emergency department, the garda, and the Taoiseach (Prime Minister) were all giving the same warning. And people tend to have the feeling that a national warning is more serious than a local warning and that local warnings do not have such fatal consequences as national warnings. ○ All the information that we are gaining from all the institutions would be part of what we are setting out to the public. So, the communications team would give out the national warning after it was issued but it would also give out specific local messages, like which roads are closed or which are already reopened, but it would also include information from Met Éireann, like updates of when the strongest winds occur and how long they will last, as well as information of the characteristics of the storm. E.g., that the calm period of wind is only the eye of the storm passing and that this is not the end of Ophelia. So, the information of Met Éireann would be used together with specified local information and handed out to the public. ○ Communication included information to people that they probably were not able to go to work, open their businesses, bring their children to school and plan accordingly. This info would be sent out via App, SM, TV, radio, and newspapers. And as stated before it was easier to communicate this to the public, because this was a national event and different national authorities and agencies were stating the same thing. Additionally, to this message, there was information given, e.g., if you have a backyard secure your furniture there, and secure trampolines. The messages for businesses were similar: secure the furniture, get hanging flowerpots inside, and for construction sites messages were: secure work material, secure poles and loose elements not yet fixed in construction, like tiles and poles etc. secure your scaffolding and cranes even better than under usual events because the wind was expected to be worse than the one that they had in man many years. ○ e.g., the trampoline and asking their friends if they have secured theirs ○ “talk to your elderly neighbours, inform them about the advice and the event. Look after them from time to time and keep them posted”. ○ one of our preparation advice: make sure your phone is well charged before the event starts. And as long as the telephone lines and the backup generators were running one would still have access to information and you might still have a battery radio, or you can use the radio on your mobile phone. Ergo this threat of losing power was communicated together with the information on how to prepare for this event (having charged phones, radios, torches, candles). This was communicated locally but as well nationwide. This was the only number that was given out in the press releases or media statements, and all calls in the building were redirected to this specific number. ○ We did give out the information to people not to handle these issues themselves and we are probably lucky in the city because this is more of a country thing. After all, in the city, not many people own a chainsaw. Still, the information would be out to call the emergency number in case of an incident with fallen trees because the CCC has the equipment and the expertise to handle the issue. So, all communication would have the contact details included and lines were open from 7 a.m. till midnight and then from 7 a.m. the next morning onwards. And during the closing time of this number, there would be the normal emergency out-of-hour number available. They ask people to stay patient and not remove the tree by themselves.

Continuing Table 26

Code\ Interviewee	Mr Joyce, Director of Operations, Cork City Council
Public	<ul style="list-style-type: none"> ○ People expect information about an issue coming on the SM channels, e.g., the notification that a road is blocked through a tree but also the information 2 hours later that the road is now clear again.
Thresholds for Com.	<ul style="list-style-type: none"> ○ on the other hand, it hindered the response because the response team teams were as well not allowed to go out during the event. The response team was only out in the morning before the event started, preparing ○ At this time response teams were sent out again, based on the meteorological information that the LCC had. ○ Crews were pulled off the streets around half past 12, this was the time when the strongest winds started to hit Cork. Thus, teams were told to shelter in their depots, because the risk assessment showed that it was not secure anymore for the teams to be out. Teams would only leave their depot when people called for help that was in a life-threatening situation ○ Otherwise, there has been constant risk assessment when it would be safe for the staff to go out again, and this was the case at 18:30 because the winds had descended to an acceptable level by then. ○ Communication started 3 days before the event, on the 13th of October. Met Éireann stated that a significant event was coming, even though the exact extent was not known then. ○ The threshold for the team was as well the red warning when it was clear that the event will be significant.
Com. Media	<ul style="list-style-type: none"> ○ since 2015/2016 Cork City Council (CCC) is using SM for public communication. By then Twitter and Facebook mainly ○ via phone. ○ SM and media briefings, like radio. The LCC would even give live interviews on the radio station to give live updates of the event, like RedFM 96 FM and RTÉ. ○ In Cork, radio is a widely used medium. Lots of people have the radio running, either in the background at work or during housework. Especially elderlies rely on the radio as their source of information. The younger cohort would be reached with SM (Facebook, Twitter), not yet Instagram in 2017). ○ In the hours before the event, during the event and in the immediate aftermath of the event timeliness is the most important thing about your communications. There is no sense in telling a person 3 days afterwards that a road is open and the tree is gone, people have found out by then anyways. And all the messages that were given out were pushed through SM, App, radio, and television stations equally. ○ There was no change in the use of communication channels. Messages were given out on all channels. ○ The LCC would also rely on informal networks, like friends ringing each other after they saw advice given out on Facebook (e.g., the trampoline and asking their friends if they have secured theirs). These informal networks are especially for people not listening to the radio or are not frequently or not at all on social media. ○ the fire department and civil defence use TETRA, not the LCC. ○ After the people were allowed to go outside again the number of calls rose. Still, the number of calls could be managed by the 8 staff people for the call centre, even though sometimes one must wait in a call queue, but never longer than 10min. The calls themselves were relatively short.
Before	

Continuing Table 26

Code\ Interviewee	Mr Joyce, Director of Operations, Cork City Council
<i>During</i>	<ul style="list-style-type: none"> ○ In the lead-up newspapers and TV was used as well. But during the event, it is your local radio, App and SM because you get your instant message out very fast ○ Teams that were not in the buildings were mainly reached via mobile phones. They were relying on the mobile phone network staying up and all the teams could be reached. ○ TETRA was not used during Ophelia. ○ But the delivery mechanism did change due to SM. ○ During Ophelia, we also were providing a lot of radio messages like hourly updates on the radio where one person from the LCC would either go to the radio station or would provide the radio with a written statement.
<i>After</i>	<ul style="list-style-type: none"> ○ Nowadays we have developed an application called “Cork City now” and people can download the app and get a push notification on their phones about upcoming weather warnings. This app became very useful ○ more recently also Instagram. ○ So nowadays there would be more communication to communities instead of individuals as another communication channel. So in case of another storm event, the LCC would use that community event and communicate as well to these communities which probably have more than 100 people in them. ○ The use of TETRA for the LCC is only beginning to develop. They have been used in one flood event. So, when there was a flood forecasted the 6-7 teams would collect TETRAs in advance and David would have a TETRA and some of the senior engineers would have TETRAs. The use worked very well; however, they use it only for flood events because it is a lot of training involved to use TETRA. The training is necessary because one needs to talk in certain ways on the radio. Ergo the coding of the different messages must be trained. If you don’t have the proper structure in place TETRA radios can be a disaster because teams would talk over each other. ○ But the delivery mechanism did change due to SM.
Changes in Com. Chain	<ul style="list-style-type: none"> ○ The communication with the LCC teams was not affected due to power outages caused by Ophelia. The LCC has a very substantial generator, about the size of a 20-foot shipping container (6.10m long x 2.44m wide x 2.59m high). It is based on the back of the fire station and can run the entire City council building incl. city hall, the new civic offices, and the fire station to 100%, like lights, electricity, heating, and computers. This was updated 10 years ago, before that the generator could barely keep the building running (heaters, most of the lights, have the computers must be switched off). It is a diesel generator which is fully filled and there is diesel storage next to it. It is regularly tested, and it switches very smoothly (less than 1sec). Ergo, in case of power loss, the CCC would be able to run full services with full communication and full power.
<i>Before</i>	<ul style="list-style-type: none"> ○ Previously the communication team would be at home and only get e-mails about which tweet should be posted. By then there were relying on David ringing them and providing them with information otherwise, there would have been no communication. ○ Now they are in the room they are part of the crisis management team; they are part of the process itself. They are now an independent third party of eyes looking at what is going on and informing the managers when they post something. Especially when there is so much going on that the managers can’t see the woods because of all the trees. And they were part of the crisis management team the first time during Ophelia, which worked really well and is set as a fixed part since then.

Continuing Table 26

Code\ Interviewee	Mr Joyce, Director of Operations, Cork City Council
During	<ul style="list-style-type: none"> ○ the LCC relied on the ESB to get out quickly and reconnect customers.
After	<ul style="list-style-type: none"> ○ So nowadays there would be more communication to communities instead of individuals as another communication channel. So in case of another storm event, the LCC would use that community event and communicate as well to these communities which probably have more than 100 people in them. ○ now there are better community links, so instead of first calling the civil defence, there might now be the community which would be first contacted instead of the civil defence. Hence, nowadays it would be a try to involve communities much more. They would probably know who has power and who hasn't and could easily look after the people without power and assist them in terms of sharing facilities. Thus, the community thing is not yet tested (because there was no major emergency event) but he thinks that this could develop into a major emergency response communication network as well in the future. They would be the people on the ground who can check for elderly people and affected neighbours.
Changes in Com. Content	<ul style="list-style-type: none"> ○ In terms of message content, there was not much change.
Before	
During	
After	<ul style="list-style-type: none"> ○ Also, one must say that red warnings are very rare, there has only been one other red warning given out since Ophelia. Yellow warnings are quite frequent, one would have 30 yellow warnings in a winter. Even orange warnings are relatively frequent, like 5-10 in any given winter. However red warnings are given out rarely, so people understand the risk and the warning worked very well. ○ This involves as well that the teams on the ground reporting back to the LCC that this road is now open again which the crews were not used to because their job is the removal of the tree, not communication.
Changes in Thresholds	
Improvement Suggestions	<ul style="list-style-type: none"> ○ But there is no training or TETRA for a chainsaw or other teams. Hence, it is considered but it is not done yet. But this would give us a level of redundancy. Currently, they are very much redundant on the private network and communication channels, i.e., mobile and landlines. If they go down the backup isn't there at present. ○ two-way communication in getting information from the public in a digestible and usable manner should be developed. It is not possible to monitor the SM posts of 210,000 people and respond to all of them. So, a user-friendly GIS map where people can see what was reported already, where the teams are currently working on and which ones are already cleared, together with the function that people can report incidences not already known of in a standardised structures manner would be beneficial. It would be nice if the app, which is now only one-way communication could have this particular feature. This tool could also be used in flooding events to show where people can get sandbags to protect against flooding and how many are available in each depot. There the forecasted flooding areas could be shown as well, and people could plan accordingly for each event. This approach would be a good way to bring the interaction between public and local authority to a higher level and this should not only be done in Ireland but should be part of a European project. This would be a possibility to create a solution for fixing this feedback loop.

Continuing Table 26

Code\ Interviewee	Mr Joyce, Director of Operations, Cork City Council
Improvement Suggestions	<ul style="list-style-type: none"> ○ What should be more developed is TETRA communication and its training. And to make sure two-way communication is in place between the on-the-ground team and the LCC and SM.
General lessons learned	<ul style="list-style-type: none"> ○ It was probably one of the better-managed events, as we involved SM and learned from previous events. One of the learnings for Ophelia was the need for immediate communication. ○ this was the big thing we learned from Ophelia the power of SM to get an immediate and instant message out there. ○ This showed us as well that we need to have our communication team on site in the LCC. ○ The use of SM was a revelation in Ophelia and is used ever since. SM postings and skimming together with our communication group on site is definitely a thing we learned during the event. ○ However, it is imaginable that people in the countryside could be affected by blocked roads when getting to appointments and the HSE did learn a lot from those 2 events when it comes to preparing patients for urgent appointments. There is pre-planning in staff organisation and in appointment relocation or coming in earlier. ○ important learning was people’s attitude towards information: people want it now, they want it accurate, and they want it regularly. They expect that even during the event there is regular communication ○ This closing of the loop is another key learning.
Challenges	<ul style="list-style-type: none"> ○ But they are still working on the fact that making clear that our “emergency” number is not misunderstood with the normal emergency number of 999 or 112. If there was a threat to life, these short numbers were supposed to be called. These would then be handled by the 3 emergency call centres throughout the country with highly trained and specialised staff (Limerick, Dublin, Mayo). However, this is sometimes misunderstood, not in Ophelia but in other events. So, the CCC tries to make clear that only in urgent non-life-threatening situations the emergency number of the CCC should be called. ○ Ergo focus was on damage to buildings, fallen trees, flying debris and items coming down and killing people. There were 500 fallen trees and 30 buildings damaged (some public ones, mainly private ones) during Ophelia in the city ○ The problem was the LCC didn’t know who did and who didn’t have power, lots of these people lost power during the red alert, so we couldn’t go out to them. So, you are right it is a problem because when they don’t have power, they did not have access to specific information.
Other NHs	<ul style="list-style-type: none"> ○ people are exhausted from constant communication and the types of events that are happening. Especially when it comes to flooding in the city of Cork. Cork is often affected by flooding. Hence, people are not concerned anymore about flooding, because Cork floods regularly. There was a particular event in 2019 where there was a significant tidal flood event expected. 3 days before the event public notices were out, warning specific businesses in the city centre to secure their stores with flood backs if they did have not any flood protection measures in place anyway. CCC knew that this event will be different from the usual events and that even Oliver Plunkett Street will be flooded, which isn’t usually affected. So the CCC targeted specifically Oliver Plunkett Street with their warnings and they were even handing out 1-page-flyers and posting these into all the letter boxes of the businesses on Oliver Plunkett Street one day before the event, just in case they were not following SM. Still, shops have been flooded, because the people did not install flood protection even though they got a warning. Shop owners were arguing “my shop was not flooded last time you warned the people” so David Joyce was replying “but last time I didn’t target you specifically to take measures, did I?”. and the reply would be “Yeah I know, but I thought you were just being cautious.”

Continuing Table 26

Code\ Interviewee	Mr Joyce, Director of Operations, Cork City Council
	<ul style="list-style-type: none"> ○ Cork City is often affected by flooding, especially tidal flooding.
Characteristics causing impact	<ul style="list-style-type: none"> ○ during Ophelia the winds didn't come together with high tides, thus there was no flooding. ○ 500 trees came down and most of them came down after the eye had passed due to the circulation of Ophelia. This was because usually Cork gets storms that come with the westerly winds, so winds came from the west, hence, during the second half of Ophelia winds came from the east. Ergo, trees which were grown to resist strong westerly winds were now hit from the east and could not resist the force of these and fell.
Info about LCC	<ul style="list-style-type: none"> ○ The LCC is located on the top floor of the fire station and consists of three rooms. In one is the chief executive of the Health service executive (HSE) and a representative of the garda ○ the communications room with the call centre people and information managers, ○ crisis management team in the big room which has the SM people included ○ Another important part of the LCC is the group of people that are only designated to take phone calls from the public on a special dedicated emergency number. ○ Now they are in the room they are part of the crisis management team

Table 27: Summary of all code segments of the interview with representatives of the CD and the fire department

Code\ Interviewee	A representative of CD & a representative of the Fire Department
Risk Com. chain	
Intra-Agency	<ul style="list-style-type: none"> ○ generate information for internal staff use
Inter-Agency	<ul style="list-style-type: none"> ○ They are partaking in the forecasting and assessment phase of incoming bad weather. They play a big part in the management and response phase of the incident and some elements of the recovery.
Inter-Agency	<ul style="list-style-type: none"> ○ there is information from national, from forecasting (national), info from engineering teams, from other stakeholders, like power generation companies. Especially the power generators are relevant for Cork city because upstream there is a power dam which has a great influence on the downstream of Lee River during severe weather, as they need to sometimes release water as a precautionary action to prevent dam overtopping in bad weather conditions. ○ Even though the fire department is still a vital part of info generation the County Council is the head of the response, they are tasked with the responsibility. And what is important about the Cork Council perspective is that they talk to the national emergency coordination group (NECG) that sits if there is a severe weather warning and there is also the national weather service there. ○ information is flowing from top to bottom and vice versa. So, there are national, local and on-the-ground levels in the chain. Which would apply to the strategic, technical, and operational levels. Also, in case of red weather warnings, these incidences are coordinated country-wide. ○

Continuing Table 27

Code\ Interviewee	A representative of CD & a representative of the Fire Department
<i>Inter-Agency</i>	<ul style="list-style-type: none"> ○ So, social media (Twitter, Facebook) is actively monitored by the media liaison officers and they will share the information with Cork City Council and the fire brigade. ○ there is a response group set up together with members of Cork City Council, the garda, the ambulance service, the engineers, the power generation stakeholder, and the fire brigade.
<i>Public</i>	<ul style="list-style-type: none"> ○ externally for social media channels. However, this generation is only the role of a secondary player. ○ They transfer information to the public through social media. The interagency media liaison officers are involved in communication with the public. They coordinate the messaging to the public and collect the information they get from the fire brigade, garda, and the council. ○ He would only dispatch the crews that are on standby according to the importance of the incoming calls. Afterwards getting information back from the teams and himself and then spoke to the control centre in Dublin which has automated control of the switches of the local networks.
Risk Com. Content	<ul style="list-style-type: none"> ○ it is key to have communication experts to the public about the recovery phase as well and give information about where the power is lost, how long it will take to restore it and as well to tell where there was work going on and when power was restored again. But also, to let people know that Cork City Council was safe and could operate as usual. So, integration of external people e.g., ESB staff to assist in messaging the public about specific matters (power losses in this case) which is specially tailored for Co. Cork and Cork city.
<i>Intra-Agency</i>	<ul style="list-style-type: none"> ○ there are different standardised advisories on how to organise the staff. Also, the risk assessment internally is done with the standard of the warning system. ○ However, as there was no power in some areas and it was difficult to reach the volunteers working in the fire brigades in rural Co. Cork, they prepared by calling in teams before the event happened in case power would have been lost.
<i>Inter-Agency</i>	<ul style="list-style-type: none"> ○ This info is more about the response the fire brigade does during the event. Something like “we have responded to 20 trees down in this area”. They give information on the severity of the incident that they are dealing with. Content would include if the warning was in line with what is dealt with on the ground or if the warning is exaggerated or minored. They give a verification of the warning stage.
<i>Public</i>	<ul style="list-style-type: none"> ○ The content of this information is true facts from national groups, like forecasts. They transmit warnings with the help of an alert level system. So, warnings are put out to the public and the businesses in the area through Cork City Council. Ergo they supply warnings, recommended advisable actions in case of an emergency and how to behave during the event. This communication happens before, during, and after an event. ○ These messages are standardised now, at least the warnings. ○ This knowledge will dictate the response and the communication to the public. Social media is a crucial point in general, because nowadays with social media everybody becomes a journalist. So, the fire brigade played a big part in the verification of information that was shared on social media over accidents that happened during Ophelia. This is done by mobilised crews that are out on the ground. There is no specific team that checks incidents reported via social media. ○ And Ophelia was the first time when a red weather warning was issued with a stay-at-home implication. It was one of the first serious events where everybody was told to stay at home. ○ saying there is a red alert, and everybody must stay at home

Continuing Table 27

Code\ Interviewee	A representative of CD & a representative of the Fire Department
<i>Public</i>	<ul style="list-style-type: none"> ○ the people and the business were forwarded the national message plus the instructions of the fire brigade and city council. ○ it is very difficult to target affected areas beforehand and prepare accordingly. Therefore, the warning was given out for County Kerry and County Cork. ○ the national warning supported the warning, that everyone should stay home ○ Even though people stay better inside if there is bad weather like rain, however, in wind conditions people like to go out for a walk, especially because it was so mild during that day. So, it is important to have the right message. ○ There has been strong messaging on how to behave while assessing fallen wires ○ The main message during a storm is still “stay inside and shelter”.
Thresholds for Com.	<ul style="list-style-type: none"> ○ According to the warning type (yellow, orange, red), there are different standardised advisories on how to organise the staff. ○ Cork Fire brigade started communicating to the public the minute the national guidance went out. If you would have communicated before that you would have seemed a bit nervous in the eyes of the public because you didn’t have that national background knowledge and support. But now with the national red alert, you feel more comfortable transmitting a nationally supported high-level warning. ○ nowadays forecasting is quite accurate within three days so we had notification of Ophelia 3 days before the event. ○ we communicate based on the threshold levels of the warnings and as this event was a red alert we kept to the thresholds there.
Com. Media	<ul style="list-style-type: none"> ○ They transfer information to the public through social media. ○ It came out in the press, on national TV, ○ there is social media for communicating with the public. ○ communicate face to face and from there, technology is used, like phones, emails, and TETRA radios, so all methods of communication.
<i>Before</i>	
<i>During</i>	<ul style="list-style-type: none"> ○ Due to power losses, the local radio became a very important communication tool. “As everyone has a radio and batteries, you know”. It was important to reach local radio, as the national radio is not broadcasting the local issues nationwide. The local radios could still be reached with calls because the city itself still had power. So, communication is through landlines, press releases, and e-mail ○ people came to the coordination centre to talk face to face, they used landlines because mobile services were not available all the time. So, one of the officers replaced its old telephone with a wire and placed it back up,
<i>After</i>	<ul style="list-style-type: none"> ○ with COVID-19 communication at national level got much easier, as communication can happen in online meetings with several participants at once ○ Additionally, due to COVID-19, nationwide meetings became easier due to the improvement of online meetings, Interagency Emergency Management Office in the Cork area where all emergency response agencies are feeding into. ○ new communication strategies are tried, to prevent people to become tired of warnings (another flood/storm). Thus, in a recent flood event people went out in the cities and into shops with leaflets warning shop owners of the flood and telling them to secure their property. This was to prevent people would miss the message on social media or would think that event is not relevant to them, but only to others. However, that was a big effort in men's and women's power to do face-to-face consultation with the shop owners.

Continuing Table 27

Code\ Interviewee	A representative of CD & a representative of the Fire Department
<i>After</i>	<ul style="list-style-type: none"> ○ There is now a text and e-mail system for the public where people can join and get the latest alert as a broadcast message to their phones, which works as an alert message. That was in its infancy during Ophelia, but it is developed now and can be included in social media.
Changes in Com.	
Chain	
<i>Before</i>	
<i>During</i>	<ul style="list-style-type: none"> ○ The communication with the staff on the ground was not done with TETRA, because there were not many TETRAs used in the fire brigade.
<i>After</i>	<ul style="list-style-type: none"> ○ with COVID-19 communication at national level got much easier, as communication can happen in online meetings with several participants at once ○ Yes, there was a change in that sense that not all red alerts portray the true scene in the local situation. So, there has to be continuous local assessment and verification of the national message. That did change. ○ Crisis management teams that have directors. This is an improvement in internal communication.
Changes in Com. Content	
<i>Before</i>	
<i>During</i>	
<i>After</i>	<ul style="list-style-type: none"> ○ Ophelia was unusual. It hit Cork accurately and had a great impact. The red alert was very justified. However, sometimes they are not justified. Emma in 2018 was a time when the alarm was not accurate. Then the red alert was lifted, but Cork was still badly affected by snow. This is a reason why local situations are implemented into nationwide messaging when communicating to the local population. For Ophelia the nationwide message was quite accurate but, if necessary, there is now a more defined message to the local population concerning the local situation. ○ Usually, in Cork City, they lift the red weather warning very late and always presume the worst had not occurred yet and communicate this to the public. Especially because red alerts are issued for Counties, not cities and Cork is the biggest County in Ireland so to which area the warning is applying is not easily said. This can only be assessed if the fire brigade is feeding information to the national red warning for the county. ○ the Cork City fire brigade became experts in forecasting and warnings of flooding. They compare their data then with the nationwide alert and can quite accurately say if Cork City is affected or not. ○ There have been two red alerts for wind in Co. Cork, one was Ophelia which was very devastating and the other one did not cause any damage and was not affecting Cork. And as people have a very short memory, they were thinking that the risk managers were not able to do their jobs properly and went out, even though the red alert was still on, and people were told to stay inside. So, it might be after this, that people think with the next red alert, the communication of the warning is exaggerated again and will not do as they have been told. Therefore, it is important to have comparative local messages, like “this event will be as bad as Ophelia” because people remember the impacts Ophelia has caused. ○ the risk communication content in terms of advice has been improved since Ophelia. Especially in terms of risk assessment in agencies. They are keeping their employees in till it is safe for them to do work in the given conditions.

Code\ Interviewee	A representative of CD & a representative of the Fire Department
<i>After</i>	<ul style="list-style-type: none"> ○ When it comes to the public, yes, standard messaging has gone out with advice like “tie down all loose objects, take down your trampolines”. So, the message has developed based on events. It has simplified to “put away your garden furniture because it will fly around”. Messages have become a bit more realistic and direct. ○ So, the simple message of the danger of the trees is implemented ever since in every warning message. ○ The importance of knowing which powerlines are transferring power to essential infrastructures like nursing homes and hospitals is key. And providers made an effort to make sure this information is available next time. ○ The mentality of risk managers has changed a lot. From not telling people what currently happens to nowadays tell them all the facts. And this is dependent on the strength of the leader of the crisis team. Due to social media, speculation starts very early so you as a risk communicator again try to get fact-based messages out as soon as possible to inform the people about what is really happening. This will result in confidence in the management team.
Changes in Thresholds	
Improvement Suggestions	
General lessons learned	<ul style="list-style-type: none"> ○ there are lessons learned there as well in terms of where your vulnerable population groups are. As a result of Ophelia, the fire brigade invested in a high number of power banks that are always charged and can be given out to the staff in case of power loss at home, so they can be reached in case of urgent matters. Technology can still assist in solving technological issues. ○ Further, there is a report after every weather event and the learning is highlighted in that report. And it’s tried to bring that learning into the trials and exercises for future events, together with local knowledge and experience gained during each particular event.
Challenges	<ul style="list-style-type: none"> ○ So, the pressure came on the power company (ESB) to restore the lines as quickly as possible. There were then issues about whom to restore the power to first. ○ But it is very hard to give a good warning about wind, because it is difficult to forecast, how long the event will be, where the wind will come from in the end, what the impacts will be exactly and how long the impacts will last. ○ National red alerts are beneficial and difficult at the same time especially in the management zone of Cork and Kerry, with a long coastline. The warning might apply to the coast, but all people inland will not be affected. Therefore, local messaging is important as well. However, they understand, why local warnings are not possible, because they will probably confuse the population if warnings get very fragmented. This would result in anger in the population.
Other NHs	

Continuing Table 27

Code\ Interviewee	A representative of CD & a representative of the Fire Department
Characteristics causing impact	<ul style="list-style-type: none"> ○ Wind can cause flooding in Cork city when the wind is coming from an easterly direction. Usually, Cork has south-westerly winds. But if south-westerly wind falls together with high tides and high pressure there is usually flooding happening in Cork due to the tide that is pushed in from Cork harbour into the city. ○ Ophelia has been a perfect storm for destruction in Cork. It came in during October, which means trees were all in full leaves, it came right over Cork City, and it did the wind direction change and brought southeasterly winds. This resulted in people having no power for two weeks even though they were located 6 miles out of the city only.
Info about LCC	

Table 28: Summary of all code segments of the interview with Ms Cusack

Code\ Interviewee	Ms Cusack, Head of the Forecasting Division of Met Éireann
Risk Com. Chain	
Intra-Agency	<ul style="list-style-type: none"> ○ The forecasters will create weather predictions and in the end issue warnings, if necessary. ○ Information was received from the National Hurricane Centre in the USA through briefings. This was the first time there have been briefings with the NHC, Met Éireann, and the UK Met office.
Inter-Agency	<ul style="list-style-type: none"> ○ Met Éireann forecasts function as guidance to the decision-makers, who will issue national warnings (e.g., yellow, orange, red) in the end ○ The NECG (National Emergency Coordination Group) was called 2 days before Ophelia, on Saturday the 14th of October 2017 and met again on Sunday the 15th of October 2017. There was a briefing with the governmental departments, the emergency services, coastguards, and representatives for energy, transport, agriculture
Public	
Risk Com. Content	
Intra-Agency	<ul style="list-style-type: none"> ○ The information would include forecast track and their confidence in the forecasts and their modelling, they would not include any advice on how to handle the impacts.
Inter-Agency	<ul style="list-style-type: none"> ○ "And there is a daily 5-day Warning briefing to customers and Government Departments. ○ Warnings will also be transferred to risk management institutions and government departments. ○ NDFEM (National Directorate for Fire and Emergency Management) also receive telephone briefings as necessary. These warnings would have a higher detail in the nuances of uncertainty. There will be more guidance on the uncertainty and the track and the impacts.
Public	<ul style="list-style-type: none"> ○ Forecasts/warnings

Continuing Table 28

Code\ Interviewee	Ms Cusack, Head of the Forecasting Division of Met Éireann
Thresholds for Com.	<ul style="list-style-type: none"> ○ These were happening 4 days ahead, three days ahead and on the morning of the event. ○ Of course, Met Éireann was monitoring the event before but communication actively started when there occurred speculations on social media. ○ "The NECG convened (physically) two days before that on Saturday 14th October. ○ There has been a red warning issued for Kerry and Cork through the NDFEM on the 14th of October 2017. There was no yellow or orange warning before." ○ The red warning was issued because the wind speeds were exceeding the thresholds set for the red weather warning so on Saturday a red warning was issued for Kerry and Cork.
Com. Media	<ul style="list-style-type: none"> ○ web/app/customers. ○ telephone briefings ○ All media in Ireland was engaged. That would include: Website, App, RTÉ, Print media, live communication of office on radio, weather forecaster on TV, NECG briefed media directly during Ophelia, and live interviews on Saturday and Sunday before the event. à Digital, print, radio, and TV were all involved. ○ The communication with the NDFEM is happening in person
Before	<ul style="list-style-type: none"> ○ In case of an emergency, there would either be Met Éireann telephoning the NDFEM or the NDFEM telephoning Met Éireann.
During	
After	<ul style="list-style-type: none"> ○ Nowadays every day at around 7 a.m. an e-mail is sent to governmental departments with the next 5-day forecast. There is very close contact. Additionally, every Monday morning there are video briefings for the governmental departments on the weather forecast for the upcoming week. ○ Because instead of the in-person briefing, that happened during Ophelia there are now online meetings. With this, you can reach more people at the same time. ○ 'Meteorologist's commentary' and we would be updating this each day along with some audio (Podcast) and video commentary.
Changes in Com. Chain	
Before	
During	
After	<ul style="list-style-type: none"> ○ That was an exception in the past, but there is a protocol in place now, that says that in case of an Atlantic hurricane heading toward Europe these briefings will happen. This protocol was set up in response to Ophelia.
Changes in Com. Content	<ul style="list-style-type: none"> ○ No need for change in communication
Before	
During	

Continuing Table 28

Code\ Interviewee	Ms Cusack, Head of the Forecasting Division of Met Éireann
<i>After</i>	<ul style="list-style-type: none"> ○ Since Ophelia, there have been several new developments in forecasting and warnings services such as Ensemble Prediction and three-day warnings with phone notifications ○ The forecasted warnings result in a better understanding of the onset, duration, and end of the warning. So, the change from one deterministic path to the ensemble forecast is a good improvement for future events. ○ Specifically, what we would do differently is to take leadership of the medium-range prediction 6 to 10 days ahead (ECMWF). We have introduced a ‘Meteorologist’s commentary’ and we would be updating this each day along with some audio (Podcast) and video commentary
Changes in Thresholds	<ul style="list-style-type: none"> ○ Thresholds were applicable.
Improvement Suggestions	
General lessons learned	
Challenges	
Other NHs	
Characteristics causing impact	
Info about LCC	

Table 29: Summary of all code segments of the interview with Mr Hand

Code\ Interviewee	Mr Hand, Senior Press Officer ESB
Risk Com. Chain	
<i>Intra-Agency</i>	<ul style="list-style-type: none"> ○ The network's operation manager will trigger activity and will call in the Networks emergency coordination group which encompasses different people, like the call centre manager, supply chain people, and area managers that are located around the Country. E.g., Cork would have 2 area managers, because of the size of the county. These people would all be informed about the upcoming event and briefed where precisely the storm will hit. ○ He would only dispatch the crews that are on standby according to the importance of the incoming calls. Afterwards getting information back from the teams and himself and then spoke to the control centre in Dublin which has automated control of the switches of the local networks.
<i>Inter-Agency</i>	<ul style="list-style-type: none"> ○ But communication was still on from the ESB side, also with a focus on the help that was requested from the UK, Northern Ireland and France to support the work of the 2,500 staff members out in Ireland to restore power. ○ also, dairy farmers were affected so ESB approached the farming press to give out information over their channels as well.

Continuing Table 29

Code\ Interviewee	Mr Hand, Senior Press Officer ESB
Inter-Agency	<ul style="list-style-type: none"> ○ There should be prior meetings with the network's operations manager. These meetings are for the entire country. So ESB is aware of the Met Éireann forecast and the potential of the red warning. Additionally, they use a private weather service called “Meteo”. The network operation team would gather their information based on what winds would be predicted and do an initial assessment of resources, and what damage can be expected. But they would never go out publicly until Met Éireann issued a particular red weather warning. Even though we are a governmental entity as well ESB would always follow the advice and warnings of Met Éireann and never lead
Public	<ul style="list-style-type: none"> ○ In the early days of the storm, the phone kept ringing in the press office, and they were getting messages from all over and even international media, like CNN, Skye News and BBC. But especially important were the RTÉ evening bulletins at 6 and 9 o'clock. ○ So, the operations managers would go out on RTÉ Radio and Television, and the area managers would go out on local radio. ○ He would only dispatch the crews that are on standby according to the importance of the incoming calls. Afterwards getting information back from the teams and himself and then spoke to the control centre in Dublin which has automated control of the switches of the local networks.
Risk Com. Content	
Intra-Agency	<ul style="list-style-type: none"> ○ there is a generation of information for the staff in terms of where to move and where the predicted affected areas are. ○ Communication with staff to move resources ○ There is a database where customers' contact details are set. There is also a database of vulnerable customers, like elderly or people who need medical equipment to survive. Thus, according to this database restoration was prioritised additionally to power masts for phone services, and facilities of Irish water, like pumps and WWTPs. Hospitals were also prioritised even though they have generators.
Inter-Agency	<ul style="list-style-type: none"> ○ Due to the long-time of 6-8 days, it took ESB to restore services there was political pressure and public pressure on ESB. So, they took the Taoiseach (President) Leo Varadkar to the sites and showed him, that they are working full force to restore power.
Public	<ul style="list-style-type: none"> ○ A press release was issued on Sunday afternoon/evening to advise people to expect damage to the electricity network, to have spare torches around, to charge their phones and to use the power checker online. With the last-mentioned tool, it can be checked when power is estimated to be restored for your particular house. ○ And there is information for the public in terms of the warning said before. But no maps are created of where exactly power losses are expected because the wind systems are too unpredictable. ○ “expect outages and give the advice to charge phones, have torches and candles ready, turn out all appliances, leave one light switched on to see when power is restored, report any damages through our emergency number, stay away from ESB infrastructure when it came down, like fallen lines, damaged poles”. ○ there weren't specific warnings for Co. Cork and Co. Kerry only. In this case that was a good approach because Co. Wexford was also very badly affected even though it wasn't predicted to be. ○ There is no specific information on how to prepare for a long time without power, like 8 days. People are taking their own decision on how to prepare, like if they can rely on family living close by that might have power, etc. ESB is relying on other channels, like Civil Defence to provide people with that kind of knowledge. Only in terms of vulnerable people, ESB would advise them to contact their health professional.

Continuing Table 29

Code\ Interviewee	Mr Hand, Senior Press Officer ESB
Public	<ul style="list-style-type: none"> ○ the call centre number was held bag a little bit to keep the line free for emergency calls and information on fallen power lines due to the vast number of calls that came in after the storm. ○ customers can see where power outages are and when the power is approx. restored. This was a valuable tool, especially when frustration started when customers have been without power for 3-4 days.
Thresholds for Com. Thresholds for Com.	<ul style="list-style-type: none"> ○ As Ophelia hit on a Monday morning the mobilisation would start around Thursday and Friday. And latest by Sunday evening it was known to mobilise and expect the worst. ○ according to the information of areas expected to be most affected ESB is moving resources (staff, materials like poles and wires) already to these areas to start a fast recovery to the network in case of damage. However, this is not always done in any wind event because wind systems tend to change very fast and can easily make landfall 100km away from the predicted area. Nevertheless, as Ophelia was a very huge wind system the resources were moved to Co. Cork and Co. Kerry beforehand. ○ Communication with staff to move resources started 4-5 days in advance. ○ And there was information to the public on Sunday evening ○ Thus, the red warning was issued on Saturday and ESB followed with the warnings on Sunday. ○ Thresholds are based on the warning system of Met Éireann. A yellow warning is quite routine and there the affected customer number would be around 5,000 which is relatively small compared to 2.5million customers. So, this gives a sense of what workload can be expected. An orange warning would be equivalent to 5,000-50,000 affected households, depending on how widespread over the country they are. But the power would be usually restored to all within 24 hours. However, a red warning is very serious, it is usually nationwide and causes severe disruption and power restoration can take several days, like in the case of Ophelia. ○ What was done (after the political pressure rose) was that a message was given out via local radio, after 5 days past the storm, that people without power could get food delivered at the costs of ESB however, that was not really used.
Com. Media	<ul style="list-style-type: none"> ○ RTÉ, as the national broadcaster is key to getting messages out ○ RTÉ Radio and Television ○ local radio ○ the messages were in newspapers ○ all these messages would be published through the ESB website, social media and through the call centre where requests came in ○ There are no push-up messages through an application or similar, but there is the website of power check
Before	<ul style="list-style-type: none"> ○ press release ○ This information was given out nationwide as a press release and went to all national and local media. ○ The customers were briefed before the event via mass media.
During	<ul style="list-style-type: none"> ○ the press releases were also locally focused, like Cork local media channels were used, not only nationwide channels. And after 8 days a press release was issued that the power for all customers has been restored. ○ RTÉs camera crews with them on helicopters

Continuing Table 29

Code\ Interviewee	Mr Hand, Senior Press Officer ESB	
<i>During</i>	<ul style="list-style-type: none"> ○ as Ophelia proceeded customers got a text message on their phones on when to expect power restoration for their house. ○ the mobile network stayed strong, so there was no issue in communicating with the crews on the ground, even though TETRA devices would be available in such a case. ○ farming press 	
<i>After</i>	<ul style="list-style-type: none"> ○ After Ophelia storm Brian was approaching, however, the people were fatigued about the messages, so the communication strategy was changed a bit, to raise the interest of the people and get the message through to the public and make them aware of a new threat. Thus, a press conference was called, instead of a press release. 	
Changes in Com. Chain		
<i>Before</i>		
<i>During</i>		
<i>After</i>	<ul style="list-style-type: none"> ○ now there are persons only assigned for communication in these teams. 	
Changes in Com. Content		
<i>Before</i>		
<i>During</i>	<ul style="list-style-type: none"> ○ Before the storm, the message was “prepare to be without power for up to 10 days” ○ after the damage occurred the press releases would repeat the warnings of the effects of fallen lines as well as the most actual numbers of how many people were without power and when people could expect to have their power back. Thus, there were probably 3 press releases a day updating people on the progress of the restoration of power. ○ in the later stages, the message changed to “we have the control, we are constantly working on restoring power, but it will take time”. ○ ESB took RTÉs camera crews with them on helicopters to make the damage visible to the population to raise their understanding of the time that is needed to restore the power. ○ crews were in charge to explain to the people that their power connection is based on another line that is not yet fixed. ○ What was done (after the political pressure rose) was that a message was given out via local radio, after 5 days past the storm, that people without power could get food delivered at the costs of ESB however, that was not really used. ○ "Do you think the offer was not accepted because people without power did not get your message? That could be a possibility as well, as centres were set up in towns, and not where the people without power are situated." 	
	<ul style="list-style-type: none"> ○ Actively monitor restoration with photographers and cameras to show the people the damage and progress at the same and publish these via social media and in the press. 	
	Changes in Thresholds	

Continuing Table 29

Code\ Interviewee	Mr Hand, Senior Press Officer ESB
Improvement Suggestions	<ul style="list-style-type: none"> ○ Trained substitutes for communication are needed. And people must be assigned tasks during the event.
General lessons learned	<ul style="list-style-type: none"> ○ A lesson learned is having greater control of the message. And numbers are a big thing, too. Thus, most recent numbers are given out before every key bulletin (lunchtime, evening) now, not every hour or on requests of journalists to make sure the numbers are accurate to the time they will be used on the media. ○ A well-equipped communication board with enough trained staff is key for successful communication.
Challenges	<ul style="list-style-type: none"> ○ For ESB Ophelia was an 8-day event as there were several press releases during that time. After Ophelia, there were 380,000 customers without power, and half of them were in Co. Cork.
Other NHs	
Characteristics causing impact	
Info about LCC	

Table 30: Summary of all code segments of the interview with Mr O'Brien

Code\ Interviewee	Mr O'Brien, Emergency Management Officer HSE South
Risk Com. Chain	<ul style="list-style-type: none"> ○ We send that warning to a single point in the hospitals, ambulance services, etc. To each point of the services, he described. Afterwards, it is up to those services to prepare for the event and pass the message down to their responsibilities. This is because for the HSE it is unrealistic to give the message to more than 4000 staff across Kerry and Cork. So, within the HSE they use a command and control or a line-measured structure to communicate. ○ The information the HSE gives is only generic. The HSE will communicate to its pillars. These pillars will then communicate further with the specific patients. that would be the communication chain they use: They use the email service of Met Éireann and disseminate this information to the key stakeholders and then it filters down through the entire health system. At least that is what is supposed to happen, even though sometimes the messages do not get to the people down the road. ○ Cian's task is to make sure that severe weather plans are up to date and that warnings are communicated to the staff as well. And the severe weather event Cian would support the crisis management team of the HSE. And the crisis management team consists of the senior managers in the region who come together to manage the emergency. The team consists of the entire spectrum of the health service, like the public health site, the ambulance site the hospital site, and the community services. So, they all come together to manage that incident. ○ can already engage with services that are critical and might be affected worst in the event (not all services in the health services are as critical as others; dialysis is one as well as chemotherapy, home help, in house services).
Intra-Agency	

Continuing Table 30

Code\ Interviewee	Mr O'Brien, Emergency Management Officer HSE South
<i>Intra-Agency</i>	<ul style="list-style-type: none"> ○ Cork has a hospital group and appointments could, if possible, be divided within the group. Where the group is the management team to support the hospitals. So, if the Cork University Hospital (CUH) or the Mercy University Hospital (MUH) have any troubles, they could communicate this to the group and the group could divide the appointments between 6 hospitals in total. But of course, every hospital has different services and thus it could be possible that your appointment is delayed on those days, even though hospitals try to fit everyone in. ○ Cian mobilised ambulances that were stationed in Cobh and made them bring the patients as far as the tree afterwards, they were carried over the tree and another ambulance to the other side of the tree would drive the patient to a hospital. Before the exchange, they needed to mobilise off-duty staff that is in Cobh to help them till the ambulance arrived and to let Cian know how stable the patients were. That was one communication he had with the local authority, again more of a management task. ○ He would only dispatch the crews that are on standby according to the importance of the incoming calls. Afterwards getting information back from the teams and himself and then spoke to the control centre in Dublin which has automated control of the switches of the local networks.
<i>Inter-Agency</i>	<ul style="list-style-type: none"> ○ He works for the HSE, but he is also in the Portfolio of the Interagency cooperation. Therefore, he works closely with the Cork city council (and the representatives of the CD & Fire Department), He works as well with Cork County Council and Kerry County Council, as well as with the garda. ○ as the confidence increases Met Éireann would disseminate a national advisory and then the national department for fire and emergency management (NDFEM) would hold a video conference in collaboration with Met Éireann. That is the time we get on board with Met Éireann ○ During Ophelia, he contacted Cork County Council not only for advice about staying shelter but as well for emergencies that occurred due to blocked roads by trees.
<i>Inter-Agency</i>	<ul style="list-style-type: none"> ○ There was an incident in Cobh where there were suddenly 3 different emergency 999 calls however the only access road to Cobh was blocked by trees. Ergo, Cobh was completely blocked. Thus, Cian needed to engage with the local authority to let them know about the issue. But they couldn't do anything
<i>Public</i>	<ul style="list-style-type: none"> ○ He is not communicating with the public. ○ He would only dispatch the crews that are on standby according to the importance of the incoming calls. Afterwards getting information back from the teams and himself and then spoke to the control centre in Dublin which has automated control of the switches of the local networks.
Risk Com. Content	<ul style="list-style-type: none"> ○ They disseminate information on weather warnings that come in at the Emergency management level to the CEOs of the pillars and these CEOs are afterwards responsible to disseminate the messages further. ○ The challenges result due to the Irish weather system because there are yellow warnings routinely. In the beginning, the HSE used to send every warning to the pillars of the HSE. However, a yellow warning is usually not sent anymore after they experienced the warning frequency of yellow warnings usually, there are no actions within the HSE and its pillars that need to be done when there is a yellow warning. As a result, the HSE organisation in Cork and Kerry only disseminate orange and red warnings, because orange and red means there is potential for disruption in services or even a potential threat to life. ○ he can only advise each hospital in their management plan but not create them for them. He can only advise things like, in case of an event bring your staff in early, let them either come to the hospital or have them booked in a hotel close by to make sure they can reach their shift on time.

Continuing Table 30

Code\ Interviewee	Mr O'Brien, Emergency Management Officer HSE South
<i>Intra-Agency</i>	<ul style="list-style-type: none"> ○ The team comes together before the event to ensure that each service has the appropriate plans, procedures, and protocols in place to deal with the event. At this stage especially the parts relevant to the event are focused on and before they approach the institutions to keep, their plans up to date and it is their responsibility to do so. ○ On the day of the event, they shut down services during the time of the warning and the event, they deal with every issue that pops up during it, like life-critical incidents. After the event, they would try the scale of that service back up as soon as possible, so those patients who have missed appointments are rescheduled asap afterwards. ○ They don't tell the hospitals how to manage themselves and don't give specific advice on how to manage themselves during a storm. They only forward the information Met Éireann gives them. At the end of this interview, you find a typical warning for a storm, in this case, storm "Eunice" from 2022, that HSE sends to the responsible health services in case of a severe weather event. ○ As Ophelia was a red warning for Monday, we asked all the staff that was working that day to come in earlier. Cian is however not sure if they really did that, but this was the advice that was given ○ So informally there would be asked something like "there might be a big storm coming next week, how are we fixed?"
<i>Inter-Agency</i> <i>Inter-Agency</i>	<ul style="list-style-type: none"> ○ We use Met Éireann as the single source of truth for severe weather ○ get an update on a real official weather forecast, ○ Under the framework for major emergency management, the lead agency for weather is the local authority. So, they also take the lead in communication with the public. If there is any specific health advice that needs to go with that then the local authority engages with the HSE communications team. So, this team is then feeding the local authority who will get out the main message. Like information where to go in case of an emergency would be part of the information HSE is giving to the local authority, but usually, it is ringing 999/112 and the note that the response might be delayed. And more importantly that there will be even a bigger delay when the services come back up, due to a lot of missed appointments.
<i>Public</i>	<ul style="list-style-type: none"> ○ On the day of the event, they shut down services during the time of the warning and the event, they deal with every issue that pops up during it, like life-critical incidents. After the event, they would try the scale of that service back up as soon as possible, so those patients who have missed appointments are rescheduled asap afterwards. ○ The relevant pillar communicates with their patients if there is a cancellation of appointments. So, the HSE is only communicating health-specific information, like cancelled appointments, and rescheduled appointments, like in the case of Chemotherapy or dialysis. In terms of coming in earlier, that is not only staff that is affected by this bidding, but also patients e.g., dialysis. ○ There are three to four shifts for that, one in the morning, one at lunchtime, one in the evening and sometimes a twilight one. Depending on when your appointment is the hospital will ask you to come in already in the morning when at lunchtime there is a red weather warning in place. This also applies to people who have an appointment in the morning; they are allowed to leave the hospital after the red warning is lifted.
Thresholds for Com.	<ul style="list-style-type: none"> ○ As soon as they issue a warning, which they do quite early in fairness, we disseminate this warning to all the pillars of the HSE. ○ Through skimming through SM he would see things early and start tracking them. Then he is starting to make plans in his head

Continuing Table 30

Code\ Interviewee	Mr O'Brien, Emergency Management Officer HSE South
Thresholds for Com.	<ul style="list-style-type: none"> ○ The procedure written above might have been one week in advance. But the action depends on the confidence of SM, and on the time of the year when the storm hit, e.g., having rain during a dry period or during a period where the soil is saturated). So, different things are considered like context (i.e., a storm in the summer month where there are marquees, trampolines, festival furniture and tents out is more critical than in the winter month, where everything is inside). However, everything they start doing is based on a specific confidence level because if you warn too early there can be warning fatigue.
Com. Media	<ul style="list-style-type: none"> ○ The warning comes through an automated system via e-mail. ○ This is done via teleconference because all the services are geographically spread throughout the country. ○ Cian reached all these people via mobile phone, ○ the base was not affected by power outages but there would have been TETRA radios as well. ○ Usually, the HSE would use SM like Facebook and Twitter and nowadays also Instagram to disseminate information. He cannot remember what was communicated there, and the content would be on a national level, not local. The HSE has a communications team, but this team is not engaging with the users but more of a giving out information service
<i>Before</i>	
<i>During</i>	<ul style="list-style-type: none"> ○ There were huge telecommunication issues after Ophelia, and these could only be overcome by driving around till the phone was charged or one got service. This was a very dangerous situation because you could not communicate advice to people. The only way to reach them is via Radio.
<i>After</i>	<ul style="list-style-type: none"> ○ And the room we were sitting in is the room where a crisis in cork is managed, which was not there 2 years ago. (In the room is a big, table, 2-3 TVs, a whiteboard and a telephone for conferences and a beamer).
Changes in Com. Chain	<ul style="list-style-type: none"> ○ severe weather planning was relatively new in the HSE there was no specific severe weather guidance in the HSE at the time. ○ There was no change in the chain, they use still the same structure that they had back then.
<i>Before</i>	<ul style="list-style-type: none"> ○ they had had troubles because up until recently the HSE has not been on the Met Éireann distribution list. They are only on the list for the last three years and during these years it was a roulette if they would receive the information and warnings from Met Éireann or not. ○ Cian himself works on the whole line of planning, preparedness, response, and recovery and luckily his task is mainly in the planning so, he works with the stakeholders to create their severe weather plans and keep them UpToDate, in place and fit for purpose. That is a bit of a struggle because it is just him doing this for Cork and Kerry. Ergo, he has 6 hospitals, the entire community service, the entire care service, and the entire ambulance service,
<i>During</i>	
<i>After</i>	<ul style="list-style-type: none"> ○ Cian started in 2015 at the HSE and it wasn't until after Ophelia that people started noticing that there should be planning for severe weather. ○ After Ophelia, there was a distinct change in approaching severe weather management. ○ What is now been done and was not in place for Ophelia is a pre-check of the facility, like the hospital, that everything works properly, and business can be done as usual. This is currently included in plans to make sure to inform people the day after the event if there are any damages to the hospital that might delay the schedule of the hospital if so, the hospital would inform the affected patients.

Continuing Table 30

Code\ Interviewee	Mr O'Brien, Emergency Management Officer HSE South
<i>After</i>	<ul style="list-style-type: none"> ○ after storm Emma, which was a snowstorm and lasted three days in Cork and 5 days in the southeast, there are now severe weather sections in the dialysis plans, where the hospital staff as well as the patient can see the procedure in case an appointment falls together with a severe weather event. Lists of prioritisations were included in the plans, depending on how exactly the timing of dialysis was scheduled. This section includes the name, address, phone number of the patient, mobility status and how far they live away from the hospital. Especially in Cork the rural nature of the county is a big challenge in planning. So, sometimes the hospital asks the patients to come closer to the city to have more possibilities to engage with people and people have less of a risk to be affected by fallen trees, and flooding during the weather event if they are already close by.
Changes in Com. Content	<ul style="list-style-type: none"> ○ The content of the messaging is as well unchanged.
<i>Before</i>	<ul style="list-style-type: none"> ○ In terms of communication, there was no protocol in the HSE during Ophelia on how to handle such an event. Ergo we needed to tell staff things that we did not previously, like telling staff to shelter in place. They were not sure if they had to do it, but they did maybe because of a lack of understanding of the impact of the event. Telling people what to do in an emergency is not our thing to do, we focus on planning, preparedness, and response but Cian is not involved in the response, he supports the management team. After the red warning, they advised people to shelter, even though one would assume with a red warning, which means a threat to life, especially for an ex-hurricane people would understand the risk. However, every time some people perceive the risk differently and think they can continue business as usual. People don't alter their daily schedule to the event and this is a great challenge.
<i>During</i>	
<i>After</i>	<ul style="list-style-type: none"> ○ Prior to Ophelia, it wasn't culture to bring staff in early, but now people see the benefits of it. This is especially the case for staff living in rural areas. They come in early and prepare to stay overnight. If someone needs to drive to their workplace for 1.5 hours it is especially dangerous in a red weather situation, but if they are close by there is a possibility that there might be a period with less wind, where staff can change shifts.
Changes in Thresholds	<ul style="list-style-type: none"> ○ The thresholds stayed the same as well, as soon as there is advice given by Met Eireann they start preparing and informing and as soon as there is a warning they disseminate the message to all pillars of the HSE. ○ Afterwards, it is often hard to do a debrief because everyone is busy getting the services back up. This is another challenge because there is no capacity in the HSE to start future-proofing, looking at strategic planning because they are so much under pressure. ○ there was another storm and there was still doubt if a red warning equals school closure. And due to what he was hearing he was unsure as well if a red warning equals closure of schools and businesses. It would be interesting to clarify if a red warning equals school closure and if yes, when did this policy come in. He believes if school closures were announced on a Sunday that this is too late, and everyone should know that a red warning equals school closures. And then perceptions play into that, too. Does a school equal a school, a nursery, a university, a primary/secondary school etc? ○ He does not know if hospitals are doing it but he would also advise patients that they might be affected by road blockings when they want to go to their appointment after the severe event and tell the patients to act accordingly and prepare them and make them aware of such a situation. This is a thing they currently advise health services to do. As well they are asking the staff to sign up for local alerts, like the cork city now app, to get information about road closures and issues around.

Code\ Interviewee	Mr O'Brien, Emergency Management Officer HSE South
Improvement Sug- gestions Improvement Sug- gestions	<ul style="list-style-type: none"> ○ clarity if a red weather warning automatically stands for school and business closure. ○ Warnings should be earlier ○ Ireland should move from a weather forecast to impact forecasting; this would overcome the issues of not knowing what a specific amount of rain means or what a specific speed in wind says. (impact can be, travel disruption, air travel disruption, damage to property, or fallen trees) ○ Have communication as well ready for people with disability, with mental health issues, in easy language, have advice ready in blind reading) ○ Have special security plans for animals, which is especially important for farmers ○ Improvement should be integrated and proactive, not reactive ○ Understand the need for childcare during a severe weather event. ○ Have framework in place where an assessment of the events performance can be carried out on ○ Have framework in place where an evaluation of the events preparedness can be carried out on ○ Have framework in place where an assessment of the new improvement can be carried out on ○ Increase personal responsibility and community resilience. à give them guidance, education, training ○ Implement something like FEMA ○ Education for emergency managers, need to be able to understand weather models and push on impacts weather warnings have on service ○ More staff working on a 24/7 rota is needed ○ Make sure health service is adequately resourced to manage severe weather events. Something like the severe weather management team in Cork City ○ Own weather observers, because Met Éireann is only giving warnings for the whole county, so own assessment of where to expect disruption locally is more beneficial
General lessons learned	<ul style="list-style-type: none"> ○ Additionally, the staff is now supported to come in early. And by now there is a Human Resources (HR) policy that if staff is coming in early, they get paid, something like a recognition of service. And the hospital in charge would book them into a hotel accommodation if they have those plans in place. ○ the HSE emergency team did not have a generator during Ophelia and just had one installed last year. ○ they did was enhance severe weather planning within the organisation. They only put information out, but it is up to the service manager to actively act on the information given by HSE. ○ There was also no change in communication they need to shift appointments. It is enhanced but not changed. This is also due to a better understanding of the procedure like patients know that they are not at the end of the queue when their appointment is cancelled but they are reprioritised.
Challenges	<ul style="list-style-type: none"> ○ However, these institutions have a lot of challenges themselves, with the care crisis, COVID-19, and health scandals. Resulting it is difficult to get these health centres to work on something that MIGHT happen as they are busy dealing with other things that ARE happening right now. Talking about prioritisation planning for severe events is not a priority until the event is happening because we are in a constant mood of firefighting. ○ Additionally, there is COVID-19 and there was a cyber attack and these events have further compounded these challenges in the health service.
Other NHs	<ul style="list-style-type: none"> ○ After Ophelia, there was snowstorm Emma and covered Cork in snow for 3 days

Continuing Table 30

Code\ Interviewee	Mr O'Brien, Emergency Management Officer HSE South
Characteristics causing impact	
Info about LCC	

Table 31: Summary of all code segments of the interview with a representative of ESNB

Code	Interviewee	A representative of ESNB
	Risk Com. Chain	
Intra-Agency		<ul style="list-style-type: none"> ○ He would only dispatch the crews that are on standby according to the importance of the incoming calls. Afterwards getting information back from the teams and himself and then spoke to the control centre in Dublin which has automated control of the switches of the local networks. ○ crews were brought in from Northern Ireland and France. When these crews came down the crews had TETRA, but they came to a point where the mobile phone network was running sufficiently already. ○ He would only dispatch the crews that are on standby according to the importance of the incoming calls. Afterwards getting information back from the teams and himself and then spoke to the control centre in Dublin which has automated control of the switches of the local networks.
Intra-Agency		<ul style="list-style-type: none"> ○ He receives information directly during Ophelia from his supervisor, who gets the information from his supervisor ○ information about the critical sites would he get via his supervisor who as well became storm manager during Ophelia.
Inter-Agency		<ul style="list-style-type: none"> ○ He himself did not receive any information directly from a cork city council management member, nor of ESB or Met Éireann. Information given to him was all done via his boss. ESB in general would have a representative in the national and council management teams to forward information to a central point in ESB. ○ He would only dispatch the crews that are on standby according to the importance of the incoming calls. Afterwards getting information back from the teams and himself and then spoke to the control centre in Dublin which has automated control of the switches of the local networks.
	Public	
	Risk Com. Content	
Intra-Agency		<ul style="list-style-type: none"> ○ how the storm is progressing, his severeness categorisation, where it is making landfall, etc. There is an email going out with the broader facts for the whole country. Also, tasks were assigned for preparation, like having staff on standby, having initial crews made up and telling them to prepare tiles and have their equipment in order, like having torches and flashlights ready, having vans fully fuelled, and having trucks fully equipped with materials. Then the local staff would gather on the premises in Dunmanway during Ophelia, ○ He does not have specific information besides the ones that come in on his screens, which are all the fault notifications of the area. During Ophelia that have been thousands of calls within minutes whereas you usually have only 9-10 calls during a busy day.

Code Interviewee	A representative of ESBN
<i>Intra-Agency</i>	<ul style="list-style-type: none"> ○ locked in his office during Ophelia and had very little contact with the outside world, he only gained some information besides the faults on his screen through the morning briefings he received regularly from the safety teams. They summarise any hazards that appeared the day before or every success and he would pass this information on to his crews. Hazards can be falling wires, falling poles, or generators that are connected wrongly. He would only structure information, like after a call is finished off, or a site is maintained safe but not restored, but it is not a priority side and can be reconnected later. ○ First, priority lines were restored where hospitals rely on or telephone/radio masts were connected to. But people with special needs in their houses were not on the priority list at first. If masts are not restored communication with teams becomes a problem as well for ESB networks, because if there are no masts in strategic spots they can't communicate with their crews anymore, after a day or two when the generators of the masts are empty. ○ He would only receive a phone call every evening from the ESB storm manager (his supervisor) to estimate the restored lines, how many are to go and when the estimated restoration time is. ○ lads are on standby and prepared with charged phones, torches, materials, equipment, van prepared till they receive information on where to go next. ○ He also gives an update briefing to the crews each morning, so they see what has been achieved and what still needs to be done in terms of customers restored and still in line.
<i>Inter-Agency</i>	<ul style="list-style-type: none"> ○ The only information he is giving out to the public is the estimated time of restoration. This is done by first restoring emergency calls, and afterwards, they check which line can restore most people if repaired again. This is first done by an estimation team, which estimates approximate times and as the repairs go on then he can estimate himself the progress he made when specific calls will be restored more accurately. ○ the media and ESB press teams would send out the advice, to stay away from faults, and use the power app. ○ Information on restoration was given to the public
Thresholds for Com.	<ul style="list-style-type: none"> ○ These preparations were done before the weekend already, like Thursday and Friday beforehand. And on Sunday evening the plans were firmed up regarding when to meet in the yard and who is covering which area, my interviewee himself the Dunmanway area and his boss the Killarney area. ○ Thursday or Friday they nailed it down that there will be a storm and Sunday they were giving instructions to the teams on where and when to meet and gather in shelters waiting for instructions. ○ Thresholds were the landfall time of the storm and the closer the event came the security of its path. ○ The red warning was definitely one of the triggers. The warning was emailed to him and he would give the info to the crews. Yellow is just a normal storm, like normal Irish weather but when it turns from orange to red you know that something is coming. ○ the lads are not sent out when there is a red warning, only when the red warning is lifted, and it is safe again to go out.
Com. Media	<ul style="list-style-type: none"> ○ Local and national media (radio, newspaper, TV, SM) would be contacted. ○ With the teams, communication is achieved via ESB-issued phones. ○ In his office, he has his work phone, the TETRA and the landline. These he would use for contact with teams and storm managers.

Continuing Table 31

Code Interviewee	A representative of ESNB
Com. Media	<ul style="list-style-type: none"> ○ We use the weather forecast from Met Éireann and the weather apps on phones. Communication for briefings is received by email and phone each day to brief the lads each morning. This is the main communication for his team and the crews. The phone calls are mainly between him and the storm manager rechecking emergency customers, hospitals, and vulnerable customers. ○ Information on restoration was given to the public by the power check app. And there was the broader media info,
<i>Before</i>	<ul style="list-style-type: none"> ○ info would be given out during and before the storm on media, news, tv, radio, and newspapers.
<i>During</i>	<ul style="list-style-type: none"> ○ with e-mails and briefings ○ He could still communicate via TETRA but there is only one per crew and not every crew would have one. ○ info would be given out during and before the storm on media, news, tv, radio, and newspapers. ○ He would only receive a phone call every evening from the ESB storm manager (his supervisor) to estimate the restored lines, how many are to go and when the estimated restoration time is. ○ Telephone service dropped down during the second day of the repairs and had difficulties talking with teams but was then using TETRA radios. Because phone service died because ESB did not reconnect fast enough, and the mast providers were not refuelling the generators at the masts soon enough. ○ 2 crews without TETRA. They will just drive to a high point where they have a signal and then send the information back to him. There were extra TETRAs brought in but only during the repairs already started and communication failed already.
<i>After</i>	<ul style="list-style-type: none"> ○ It is an internally used app for the restoring teams that they use to inform what is required for repairing the site.
Changes in Com.	
Chain	
<i>Before</i>	
<i>During</i>	
<i>After</i>	<ul style="list-style-type: none"> ○ after Ophelia, there were adjustments and roles are much clearer during a storm than before. This training course was issued last year or the year before. So, roles for each person and their tasks are much clearer now. ○ The only new thing is the new role people become during the storm, he himself would change from Customer Service Supervisor to Storm restoration manager.
Changes in Com.	
Content	
<i>Before</i>	
<i>During</i>	

Continuing Table 31

Code Interviewee	A representative of ESNB
<i>After</i>	<ul style="list-style-type: none"> ○ which might be different now with Corona, and then the staff would wait at home for further instructions. ○ the management of double incoming calls was improved. Now there are not 2 crews anymore send to the same fault. The outage management screen was reframed and the best scenarios of how to run a storm are trained with each person. Duplicated calls were now directly put to the original call and 2 teams are not going out to the same fault site anymore.
Changes in Thresholds	<ul style="list-style-type: none"> ○ No change in thresholds for the start of preparation and communication. The guide is the accuracy of the forecast from Met Éireann.
Improvement Suggestions	<ul style="list-style-type: none"> ○ "The only issue that is still there is that they rely highly on mobile phone service. Even for the app, they need an internet connection thus lads could only send the work packages back at night when they were home and reached mobile phone service. So, he would prefer to have better backup generators at mast sites." ○ He would like to have more TETRAs, preferably with every crew member or at least with every crew.
General lessons learned	<ul style="list-style-type: none"> ○ Yes, ESB set up an evaluation group to check how the storm was managed, especially each person's role in a storm.
Challenges	
Other NHs	
Characteristics causing impact	
Info about LCC	

Annex 5 – Results of Expert Ranking for Improvement Suggestions

Table 32: Results of expert ranking for each improvement suggestion

Improvement suggestion	E1	E2	E3	E4	E5	E6	Sum	Mean
Include behavioural advice into risk communication before the natural hazard hits and advice on how to organise for impacts afterwards, as well as reasons why orders and advice are given.	3	3	9	2	2	1	20	3.33
Have education and regular training for citizens for emergencies which starts in school education.	1	4	3	1	7	7	23	3.83
Have impact forecasting instead of weather forecasting.	2	6	5	5	6	6	30	5.00
Have a user-friendly GIS map where people can see which incidents are reported, which are cleared, where teams are currently working on, and where people can report incidents in a standardised structured manner.	10	11	2	6	1	2	32	5.33
Have specific communication for people with disability, mental health issues, blind people, etc.	8	7	12	4	3	3	37	6.17
Have more staff working on a 24/7 rota in emergency management, especially if warnings are coming in on weekends.	4	10	1	11	10	5	41	6.83
Have a sufficient amount of TETRA radios available to provide every crew with at least one TETRA.	7	8	7	12	4	8	46	7.67
Have clarity if each red warning equals school and business closure and be concrete about which educational services are included in “school closure”.	12	9	10	3	9	4	47	7.83
Have regular training for emergency managers and response teams on how to interpret weather maps.	5	13	4	13	5	12	52	8.67
Have regular training for emergency managers and response teams on how to use TETRA radios.	13	5	8	8	11	9	54	9.00
Have childcare available for people in system-relevant employment who also work during red warnings.	6	2	11	14	13	11	57	9.50
Have larger backup generators at masts that provide mobile service.	11	12	13	7	8	10	61	10.17
Have a central building in each city/town as a supply centre and shelter with a generator, where people can get hot drinks and food or where necessary goods can be delivered to.	9	14	6	9	12	13	63	10.50
Have special security plans for livestock.	14	1	14	10	14	14	67	11.17

